REHABILITATION, RE-EDUCATION AND REMEDIAL EXERCISES

REHABILITATION, RE-EDUCATION

AND

REMEDIAL EXERCISES

by

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With a Foreword by

LORD HORDER

G.C.V.O., M.D., F.R.C.P.

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ALL THOSE WHO ARE INTERESTED

IN PHYSIOTHERAPY

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FOREWORD

If it be true, as the author of this book says in her preface, that a lecture of mine in 1927 proved an inspiration to her when she was beginning her remedial and re-educational studies, it is perhaps not unfitting that I should write a short foreword to this manual, which sets out the mature developments of her pioneering work. To have provided a stimulus to this work gives me a good deal of gratification.

Reconditioning and rehabilitation are in the air; with many folk who pay lip-service to these ideas they remain in the air. In Mrs. Guthrie Smith's book we "get down to brass tacks," we follow the special techniques that are appropriate for particular cases and we realize the extent and the intensity of modern developments in physiotherapy. In this development the special work of the author in the direction of "suspension" methods naturally takes a prominent place; the book gives the first full and authoritative account of these exercises that has yet appeared.

But here, as elsewhere in this book, the active and volitional element is always to the fore, thus maintaining the principle that the patient's own participation in the movements should form a conspicuous contribution, both on physiological and psychological lines, to the re-education that is being aimed at.

The supplementary chapters on joint manipulation, recovery after fractures, rehabilitation methods in chest and maternity cases, electrical treatment and occupational therapy, all written by colleagues distinguished in their particular subjects, add greatly to the value of the book, and make it a very complete, if not the only complete, text-book on the subject.

No one who has not seen Mrs. Guthrie Smith at work can appreciate the amount of patience and ingenuity that have gone to the preparation of this very practical and helpful book. To wish it success seems almost superfluous.

HORDER

17th September, 1943.

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PREFACE TO THE SECOND EDITION

It is a cause of great satisfaction to me to find that the methods of treatment and techniques advocated in this book have, since its first appearance some five years ago, come to be accepted and practised in many countries other than our own. Suspension apparatus is now installed in many of the " Veterans' Hospitals " in the United States of America. The University Schools of Physiotherapy in South Africa, New Zealand and Canada teach and practise these methods in their Hospitals, and recently I have heard from China, Bombay, Persia, and Germany, of similar activity.

Meanwhile I have designed new mobile apparatus to meet the need of the bed-fast Rheumatic and Geriatric patient. Full particulars of this apparatus with illustrations of it in use have been included as an appendix to this edition. Other contributions, included for the first time, deal with Arthroplasty of the Hip Joint, Osteo-Arthritis of the Hip, and Rehabilitation after Injuries to the Spinal Cord and Canda Equina. Another appendix which it is hoped will prove useful to the practising physiotherapist provides a chart of the postural drainage positions for chest conditions, showing the correct posture for the drainage of any particular area.

Minor corrections and alterations have been made throughout the book to bring it into line with current practice.

O. F. Guthrie Smith.

Orleans,
West Mersea, Essex.
July, 1949.

FROM THE PREFACE TO THE FIRST EDITION

I have attempted to show that the treatments set out in this book are based upon a combination of *three principles*—Psychological, Physiological and Mechanical, and that they require a definite technique. Although apparatus is largely used, it is hoped that its use will remain individual, and that the exercises will not be allowed to degenerate into mechanical actions. Some case histories are given of patients treated by these methods at St. Mary's Hospital, W.2., and in the E.M.S. Hospitals.

The early chapters deal with early rehabilitation, the middle portion progresses to stronger work and games, while the third part is occupied with passive treatments. This order is deliberate as the emphasis is on self-activated movement.

As long ago as 1927 Lord Horder delivered a lecture to the Chartered Society of Massage and Medical Gymnastics which gave a purposeful and lasting inspiration to myself and others, and I would recall his actual words. He said :—

" Again and again I see the value of simple, patient re-education of *voluntary* efforts. I would change a great deal of so-called ' passive movement ' for a very little active movement under supervision. Of course, there are many cases in which the whole movement must be entirely passive to begin with : arthritis in which the muscles are much atrophied, and certain affections of the heart, are examples of this. But I think it is most important to recognize that stage in all such conditions when the patient may with benefit begin to participate voluntarily in the movements. No amount of massage, and no amount of electrical stimulation of whatever kind has the same physiological value as the natural movement carried out by the patient under supervision and careful guidance. This is a principle that should never be lost sight of.

" Since your work is based upon science, and is done scientifically, remember it is capable of growth and of improvement. . . . It is for you to advance your science by making observations and by painstaking research. . . . Do not underrate the scientific

side of your work. You should study constantly to make your work as thorough and scientific as possible."

When these words were spoken, my ideas of treatment were very nebulous and unorthodox, but nevertheless were in exact keeping with the advice Lord Horder gave, and I was thus encouraged to continue.

I would like to express my gratitude to the Medical Staff of St. Mary's Hospital, London, W.2, for whom I have had the honour of working between two great wars, and more especially to Mr. Dickson Wright who has always been interested in new ideas and urged me to persevere with the more scientific aspects of my work.

I and those who worked with me at St. Mary's were fortunate in being under the direct charge of the late Dr. Justina Wilson, who in addition to being a pioneer of electrotherapy, understood every aspect of the branch of physiotherapy which we were investigating. With her brilliant teaching, leadership and influence, those of us who were her pupils and on her staff could not fail to catch her enthusiasm or admire her pioneer work. She has earned the gratitude and affection of us all.

But this book is not all my own and I am much indebted to a number of distinguished men and women who have contributed chapters on their specialities, thus enabling the scope of modern physiotherapy to be revealed in a way which would have been impossible for a single writer to express. Their names and the subjects on which they have written are included in the table of contents, and to them I am most grateful, not merely for their contributions but for their friendship and help extending over many years.

O. F. G. S.

Swedish Institute,
South Kensington.
September, 1943.

REPRINT NOTE

This new reprint has given the opportunity to make a number of necessary minor corrections to the text and has made possible the inclusion of illustrations of the following apparatus :—

The "Transportable"—a full Suspension Frame, which can be put together and taken down in a few moments.

The "Universal" Sling-Suspension apparatus.

The "Hoist"—an apparatus adapted from Suspension for use by those who have to look after an incapacitated patient either in the home or in hospital.

The "Bed-Chair"—a chair which gives comfort and support while reading, eating and resting, and which can be used during convalescence, and also for the carriage of patients and, when fitted with trolley, for transporting them over a distance.

O. F. G. S.

Orleans,
West Mersea, Essex.
October, 1951.

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LIST OF CONTRIBUTORS

Original Drawings by MISS DOROTHY TALBOT, M.C.S.P.

NAMES AND ADDRESSES OF MANUFACTURERS OF APPARATUS

(1) STANLEY COX & CO., LTD., 11 Gerrard Street, Shaftesbury Avenue, London, W.1
Supply all types of Suspension Apparatus and the Accessories, also the author's Bedchair and Hoist.

(2) THE ELECTRO-MEDICAL SUPPLY CO., LTD., 209B Great Portland Street, London, W.1
Supply the "Standard" Suspension and its Accessories.

REHABILITATION, RE-EDUCATION, REMEDIAL EXERCISES

Chapter I

INTRODUCTORY

"Rehabilitation covers the whole range of treatment of the injured person from the time of the accident to the point when his condition is restored to the pre-accident state, or until the fullest possible restoration has been effected."

Even this definition, taken from the Report of the Inter-departmental Committee on Rehabilitation of Injured Persons, is too narrow. Anatomical structure deteriorates and physiological function is lost from disease as well as after injury. In its widest sense, therefore, rehabilitation seeks to reinstate both sick and injured human beings to their normal habit of body and mind. Obviously it must include every therapeutic process which works in this direction, and physiotherapy is only one of these.

It is realized that the subject of rehabilitation has become so vast and wide that the part which can be played by physiotherapy, though absolutely essential, is limited within the general scheme of reconstruction.

One of the first steps in rehabilitation is to awaken the will to recovery and to obtain co-operation. From the first day in hospital the patient's mind is turned towards improvement. Unless absolute rest is necessary he is called upon to exert conscious effort on his own behalf every day, even every hour. His interest in inducing the return of power by his own perseverance must be stimulated and encouraged.

Having obtained the co-operation of the patient, his actual treatment will be the outcome of the co-ordinated activity of a team of experts, medical and physiotherapeutic, whose work will not end until he is fit for discharge and normal work. The physiotherapist's part in this co-ordinated plan is ever-growing in its scope. Recently its growth has acquired tremendous momentum.

So simple is the warp and woof of physiotherapy, but the weaving of the complete pattern is often one which may require much patience and intelligence, and sometimes not a little originality.

It is impossible to separate the three subjects of re-education, remedial exercises and rehabilitation, since each is a part of the complex pattern made up by physiotherapy in all its forms. It would, however, be possible to observe and pick out certain characteristics by which the work is differentiated.

Re-education is the very warp of physiotherapy, and, like the warp, a fundamental. Every re-education treatment for the paralysed or helpless must be reduced to fundamentals and then carefully built up. Every assistance that can be given to a helpless patient should be thought out, and employed till that degree of function has returned which makes the application of progressive graded resistance a necessity. At this point remedial exercises come into their own; remedial exercises, including the Swedish system, are specialized exercises, arranged to cure or overcome a particular disability; perhaps by stretching a tight structure, joint, muscle, or localizing some particular movement for a therapeutic purpose. This work is usually carried out *by* the physiotherapist on the patient, mainly by manually assisted or resisted exercises. Of such remedial work is the woof made and it is completed at the *very moment* that the patient is able to carry out remedial work under his own power, then the process of rehabilitation by "self-activity" will have started, but will not be complete until the subject is restored in vigour "to the pre-accident state."

Muscular activity carefully graded to suit each stage of recovery will be the basis of the physiotherapist's contribution to rehabilitation. Every new activity, however small, is a point gained, and it is by accumulation of such points that progress is made. Throughout disablement, patients are thus able to *work* for recovery, building up under skilful direction the powers lost by sickness or injury.

The chief object ot this book is (*a*) to show the scope of work that a physiotherapist is called upon to undertake in general and special departments; (*b*) to try to fill some of the gaps in physiotherapy; (*c*) to advocate the use of self-activated movement.

(*a*) On the one side there appears to be a lack of early rehabilitation exercises suitable for treatment in the earliest stages of loss of function. While active voluntary work is our objective, it is not always easy to obtain. This is especially the case when patients may be ill, weak, and very disinclined to perform exercises. Our work is to make such gradation of exercise possible, so that patients' confidence is gained and their co-operation and interest enlisted.

On the other side there is the absence of strong, progressive muscle-developing technique which must be employed to fit a man for strenuous employment.

It appears that one thing is needed that will bridge *both* these gaps, and that is the insistence upon active work. Active movement carried out under supervision is the only safe treatment for conditions such as recent injuries. Even for the paralysed it is only by voluntary movement that restoration of function can be achieved. This is also true when dealing with strong rehabilitating exercises ; these must be carried out under voluntary power, the muscles acting against resistances which are continually progressed in strength. Strong exercises can also be disguised in many ways as games ; or some useful occupation such as digging or hewing wood.

(*b*) *The gaps in physiotherapy* appear to be due to various causes :

(1) To certain limitations of the Swedish system on which our English physiotherapy is grounded.
(2) To an old prejudice against " apparatus."
(3) To the lack of that class of work designated as " self-activated."

(1) It is necessary to understand the basis on which the training of medical gymnastics is founded. Apart from many of the medical subjects included in the training, there is the fundamental study of Swedish gymnastic movements. The principles on which these exercises are founded are excellent and have never been surpassed, although they have frequently been copied. In theory the system is scientific and logical ; precise principles are laid down by which progressions of gymnastic work can be built up in " schemes " or prescriptions. But the practical application of this system was originally carried out in Swedish clinics, and was mainly adapted

for walking patients of the orthopædic type, so at many points the system does not cover the problems met with in dealing with the sick and injured, the paralysed, or the need of those requiring relaxation.

While appreciating in full all the excellent points of the Swedish system, it is now necessary to be frank and admit its limitations. One of the chief of these is that the operator tends to work *on*, rather than *with*, the patient. Moreover, resistance exercises being manually applied can never be sufficiently sustained : nor can they provide the speed and tempo of the work necessary to render a man fit for strenuous occupations. Thus there is a very large gap in the later stages of treatment that has not so far been filled, and we must add to the curriculum other suitable methods.

Therefore we may expect to see the pendulum swing sharply over in the direction of hard exercise of a nature entirely new. Such work will take the form of outdoor occupations, games, physical training of a strenuous type, and persistent, careful muscle-training against resistances, such as are indicated in this book.

(2) A second gap has been encountered by the physiotherapist who has for many years been hampered by prejudice against any kind of exercise with apparatus. This prejudice dates back to the war of 1914, when the Zander apparatus was rightly rejected by a Government committee, because it was cumbersome and expensive, and, above all, too mechanical. From that time the tendency was for all apparatus to be looked upon with suspicion ; and prejudice dies hard.

In consequence, for many years there has been a lack of appreciation and use of simple appliances (which are but convenient and useful " tools " in the hands of a skilled therapist) for purposes of re-education of movement and rehabilitation.

Prejudice has now been overcome, and for examination purposes candidates require a working knowledge of exercises carried out with simple apparatus, remedial games, and some knowledge of the principles underlying occupational therapy.

(3) Lack of " self-activated " work has been the most serious gap for two decades. A tidal wave of electrical thought and apparatus swamped active work, and pushed it into a secondary

place ; thus it has come about that the usual practice has been to combine massage and electricity, and to add but a few exercises to complete the treatment. The results have often been poor, because these measures do not encourage the patient to exert himself, but make him rely on external help.

This limited application of gymnastic therapy has been a matter of no small anxiety to the teachers of the Chartered Society of Massage and Medical Gymnastics, who have been concerned to see what little use was made of the elaborate gymnastic training given to pupils in the schools. The graduates, when they passed on to posts, were not expected to encourage self-activity in their patients, originality was usually discouraged, and the orthodox treatments in the majority of hospitals, even in the teaching establishments, became stabilized at far too slow a tempo.

A re-orientation is taking place, and the emphasis is now on progressive activity rather than passivity, while making full use of combined treatments and all the valuable electrotherapeutic knowledge which has been acquired. The training in physiotherapy, while continuing on the old sound basis, now incorporates new methods, so as to fit in with a more robust type of work required by the modern conception of rehabilitation.

(c) *To advocate the use of self-activated movements.*—This form of activity has the advantage that the subject will have no fear of being hurt, as his actions are self-controlled.

Simple appliances which balance out mechanical hindrances are helpful. They aid rhythmic movement and also have the advantage of assisting relaxation, especially that reciprocal relaxation of the antagonist muscles which is so important to obtain after trauma. Apart from these factors on the physical plane, there is the underlying aspect of increased self-respect and improvement in morale which comes to patients who feel that they are co-operating in their treatment and consequently, a stirring up of hope, of better health, and better functioning will arise within them. If this psychological moment can be taken advantage of and they can be induced to co-operate in their own cure, the helpless and even crippled patients are encouraged to help themselves, rehabilitation of muscular function will have begun, and indeed need never go back.

There are many ways in physiotherapy of overcoming difficulties and of encouraging the patient, and the methods now advocated have at least the advantage of a background of time and of proved results.

As long ago as January, 1931, the writer, in collaboration with Sir A. E. Porritt, K.C.M.G., of St. Mary's Hospital, published jointly a short article in the *British Medical Journal.* It was suggested that safe early active movements could be given to patients if they were first of all suspended from an overhead bar, so that the injured part was " floating in air." In this zero position gravity is balanced out, and friction entirely eliminated ; weightless exercise is achieved.

At that time the treatment was limited to the limbs and only such cases as recent injuries and paralysis were indicated for its use. Since the publication of that article, this system of exercise has been greatly developed, and extended to cover many purposes.

It now includes the suspension of the whole body, to promote relaxation and the early rehabilitation of the sick and injured. It is also used for re-education of movement in general paralysis. For these reasons a stable framework has been designed.

The framework also affords fixed points from which certain corrective and manipulative effects can be produced, by using gravity to assist the correction and offers multiple fixed points for the attachment of spring and pulley systems, so that they can be used at any angle for muscle strengthening exercises.

This new technique has been developed with the use of varying resistances, using long and short graded springs. These resistances *added* to suspension methods have given us a new conception of what can be done in the way of rehabilitation exercises. These can now be down-graded to suit the warded patient, or up-graded to suit the strong convalescent. The muscle-toning properties of this new work complete a series of exercises in a satisfactory sequence leading from weakness to strength.

THE PHYSIOTHERAPIST

In Great Britain training in medical gymnastics is well grounded, and covers a wide field which has been tested by searching examinations; once qualified, the graduate is entitled to be registered as a "chartered masseuse, or masseur, and medical gymnast," and to become a member of the "Chartered Society of Physiotherapy."

In view of the changes of treatment envisaged in rehabilitation schemes, it is now necessary to incorporate some fresh ideas and subjects into the training. Various suggestions are made throughout this book, but, for the moment, there is one very important point, as it is fundamental to rehabilitation *; this is that "*all physical methods of treatment are educational* in character," and that every physiotherapist should be one who really teaches the patient, and not only one who merely carries out a prescribed treatment.

In gymnastic circles, both in colleges and in the Army, the educational side of training is greatly emphasized. An army gymnastic officer told the author that any soldier could be cured of faults in fighting technique solely by gymnastic methods of correction. He instanced a case of faulty and bad marksmanship, saying that this could be cured by appropriate drill by the physical training instructor; and that men after a period of such instruction returned to their units and were able to gain first-class certificates as marksmen. Bad marksmanship then is not only a matter of eye, but may be due to faulty balance or inaccurate muscle work. This is by no means an isolated or exceptional instance of the value of gymnastic teaching. Therefore it is undoubtedly as a teacher that the physiotherapist must approach the patient; and the function of a teacher is to make things easy and interesting for the pupil. The teacher must be able to demonstrate what is required, and have in the mind's eye a clear picture of the end in view.

Furthermore, physiotherapists must be thoroughly familiar with kinesiology (the science of living movement) and all its attendant problems—leverage, fulcrum, resistances, equilibrium, lines of gravity, and how these relate to each other. They must know how to compose exercises from fundamental and derived positions, and

* Lord Horder. In the Founder's Lecture to the Chartered Society, January 1927.

to select from these suitable work for the patient's age, conditions, and complaints. Also there must be a thorough understanding of muscle re-education, and ability to assess the effects of gravity on the patient.

Exercises are graded by the skill and resource of each operator, who introduces small but subtle changes in treatment, based on an understanding of living anatomy and on the principles of kinesiology. The change of base, the simplification or complication of muscle work in its relation to gravity, the variation in the angle at which muscle work is carried out, alteration of the speed and of the number of times the movement is performed throughout the day, are all-important variables in the grading of exercises. At the same time it is both a written and unwritten law that all " chartered " physiotherapists work under medical direction only.

PSYCHOLOGICAL CONSIDERATIONS

It is well known that in ill health a patient is more receptive to suggestion than in good health. Therefore, what is said or done will have a very definite effect on the patient, be it for good or ill. We must see to it that everything we say or do stimulates hope and self-reliance, and our first aim must be to make the helpless help himself. For this and other reasons the personality of the physiotherapist is of the greatest importance. Given enthusiasm and vitality, deeds and words will be constructive, and carry conviction. Physically, strength, health, and gentleness are essential for the work ; also skill with the hands must always be directed by the brain. The mental outlook must be observant and sympathetic, so that a close knowledge can be acquired of the difficulties, physical, mental, or moral, which concern the patient. The understanding of these may well be of as much assistance in dealing with a case as the more direct remedial work.

Physiotherapists must have a deep and practical desire to help their fellow creatures, and to realize that the way is often long and tedious, especially when dealing with chronic cases. The chronic patient, above all others, depends on our profession for help in the restoration of function. So much can be done for these cases, if only they are treated in the early stages of their disabilities, and

taught to carry out self-activated exercises with or without simple apparatus. This early work can often prevent that state of mind arising which is liable to become resigned to inactivity.

The whole art of rehabilitation is *to put the responsibility of his own salvation on to the patient, while at the same time making it possible for him to accept this responsibility.* Thus the physiotherapist must show originality and ingenuity, and these qualities should be encouraged from the first moment of training, and not stultified by orthodoxy.

Each type of patient has his own psychological difficulties, and every experienced physiotherapist is well aware that certain reactions appear to go with certain complaints. To be a good rehabilitator the physiotherapist must be constructive in outlook. On hearing the doctor's diagnosis of a case, the mind will be alert with certain expectations as to what may have to be undertaken. A quick analysis of *why* the patient cannot function will be the essential issue; this often means a ready knowledge of "living anatomy" and a sympathetic understanding of the disability, combined with the ability to put oneself in another person's place and see his point of view.

An essential requisite for rapid recovery is a helpful and hopeful attitude of the patient's mind. He may be depressed or bored and filled with self-pity. Up against this deranged mental or emotional outlook progress will be slow; the state of mind indicated above will be found to present severe hindrances to recovery. Something must be done to interest such a patient. He may like to be an object of interest to others in the ward, and be proud and pleased if something unusual is done to him; he may react well to special treatment, and co-operate in his own cure most willingly, especially if an apparatus is employed that he can see and handle, and the use of which he can discuss. When the patient has learnt to use the appliance, whatever it may be, whether a piece of needlework or a remedial apparatus, some personal responsibility should be put on him to continue the work in his own time, and he is thus stimulated to show progress and good results on a subsequent occasion.

Patients who do not react to this approach and dislike any sort of publicity must be persuaded by other means to attain the same

end, and, above all, be taught to rely on their own efforts rather than on those of the physiotherapist or nursing staff. On no account must a patient be allowed to acquire the habit of being a " cosy invalid."

The psychological difficulties met with in such a case must be sympathetically considered, for all patients require encouragement. Everything possible must be done to counteract a pessimistic or negative outlook, to substitute for it an attitude of intelligent interest in the problem of the case in hand, and of optimism with regard to the outcome of treatment. A powerful stimulus to this end is the employment of remedial methods that compel the co-operation of the patient, and particularly of those methods which are capable of being controlled by himself and which enable him to judge of any progress actually achieved.

In a case of total paralysis, the shock of the onset induces a defeatist condition of mind. This is especially noticeable in adult patients who suffer from acute depression. The mere suggestion conveyed by the term " paralysis " induces a feeling of helplessness and hopelessness. Often these people have to contend with the distress of friends or relatives ; they feel " different," laid aside, and it is a long time before they can adjust themselves to their changed circumstances. With hope abandoned, they are apt to give up even the feeble attempts at movement of which they may really be capable.

In all cases of severe disablement it is most helpful to demonstrate any visible movement that may result from the patient's tiny efforts. This has a profound psychological effect, even though the operator may have to " assist " the effort that produces the movement. It has been observed that the morale of the patient immediately improves where such practical encouragement can be given. It is helpful to explain that, after all, paralysis is a relative term and that recovery may be only a matter of time and patience. In this way, patients are stimulated to make every effort.

For the totally disabled, the best assistance that can be offered is the renewal of hope : indeed, therein lies the secret of continuous progress and of ultimate success.

For those cases who have made a good recovery and are suitable for strong rehabilitation exercises which will fit them to return to

work, a robust and practical psychology will be very helpful. Such patients must be kept interested in their progress, records of improvements must be put before them, and a spirit of competition encouraged ; perhaps even their powers of leadership may be brought out so that they may help others while helping themselves.

As the ultimate object of rehabilitation is to return the patient to the pre-accident state it is not sufficient merely to relieve pain and restore movement, but the restoration of full muscle power is necessary, so that the patient can be discharged, if possible, from the hospital directly back to his or her occupation.

The power required in the muscles of any individual will be in direct proportion to the work that they are called upon to perform ; therefore, it will be necessary to understand the patient's occupation and to analyse the muscle work involved in each such occupation. In investigating this data, the disability must of course be taken into due consideration. If careful measurements are made on the two sides of the body, and a full test given of the range of joint movements, then the muscle power can be tested against weight-and-pulley devices. It is then usually easy to see how far below par the actual injured side has become. Appropriate exercises will then be thought out, and the muscles can be worked either individually or in group actions, with or without apparatus as the doctor indicates.

Chapter II

SOME REVISION OF KINESIOLOGY, ANATOMICAL AND PHYSIOLOGICAL MATTER UNDERLYING PHYSICAL TREATMENT

As a major part of the exercises in this book depends upon the correct analysis of movement, and the ability to reduce movement to its simplest form, it has been thought as well to revise the subject of planes, axes and ranges of movement. From these fundamentals it is easy to build up, this is one way by which muscle work can be progressed in remedial gymnastics; it is of particular importance when dealing with weak or paralysed patients.

PLANES AND AXES

Planes

All forms of physical exercises consist of a number of complicated bodily movements. No movement can be explained without reference to two factors:

(1) The direction of movement and the plane in which it takes place.

(2) The axis round which it takes place.

Therefore, to avoid misunderstanding these points are now revised.

For purposes of description, the body is assumed to be in the anatomical position, *i.e.* in the erect position, with arms by the side, palms of the hand facing forward (Fig. 1, A).

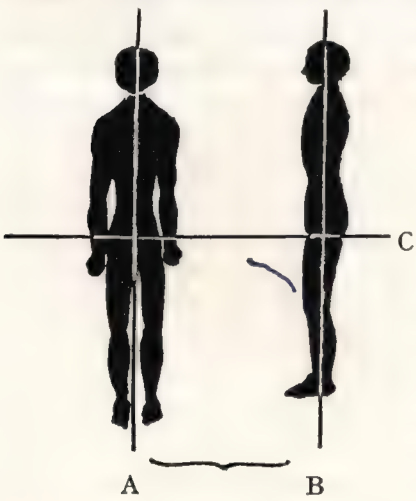


Fig. 1.

(1) **The vertical plane** (Fig. 1, A).—The *central* or *median plane* cuts through the centre of the head and body, viz. through

the umbilicus at the front of the body and between the buttocks at the rear. The limbs are disposed symmetrically to right and left of this plane. Any vertical parallel to this is called a *sagittal plane* (Latin *sagitta*, an arrow), the median plane being thus the central sagittal plane.

(2) **The frontal plane** (Fig. 1, B).—A vertical plane at right angles to the median plane is called in gymnastics the *frontal plane.*

The central frontal plane divides the body into front and rear portions.

(3) **The horizontal plane** (Fig. 1, C).—Any plane at right angles to both the sagittal and frontal planes is known as a *horizontal plane,* and can be at any level of the body.

Movements of the body or limbs can take place in any of these planes, or in more than one at a time.

Axes

An axis is a pin, hinge, or a real or imaginary line round which parts of a body are symmetrically arranged, and round which they rotate; as a wheel, for instance, turns on its axis (Fig. 2). Axes are always at right angles to the planes of movement connected with them. There are three axes:

(1) **The vertical axis** (Fig. 3, A, A[1]).—All rotation movement of the body, head or limbs occur round a vertical axis. The body has a vertical axis at the point where the sagittal and frontal planes bisect. This can be imagined as a straight line or rod passing centrally from the crown of the head to between the feet (Fig. 1, A).

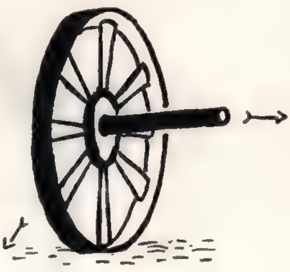


Fig. 2.

(2) **The sagittal axis** (Fig. 3, B, B[1]).—The sagittal axis passes in an antero-posterior direction. Around this axis movements in a frontal plane take place, *i.e.* trunk side-bending and arm abduction.

(3) **The frontal axis** (**transverse axis**) (Fig. 3, C, C[1]).—The frontal axis which passes in a transverse direction lies at

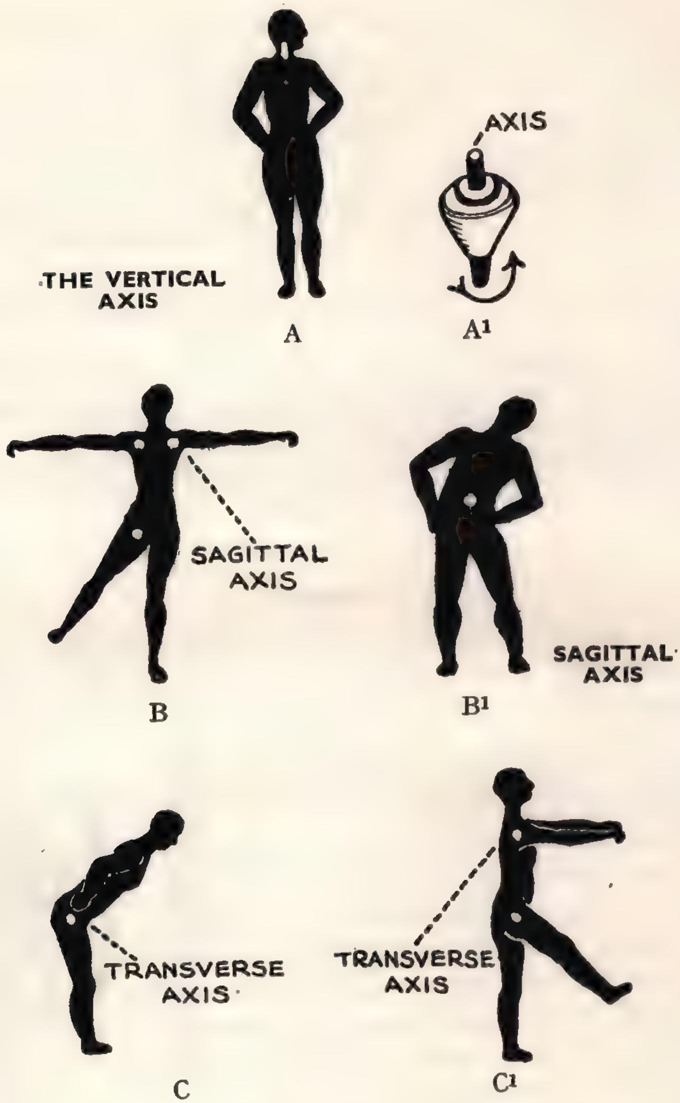


FIG. 3, A to C^1.

right angles to the vertical and sagittal axes. Movements taking place round this axis are in the sagittal plane—*i.e.* leg forward flexion and extension at the hip, trunk forward and backward bending. The illustrations help to make this clear.

Classification of Joints according to their Axes

Mobile joints can also be conveniently described by the type of movement of which they are capable.

Uniaxial joints are those joints capable of movement round one axis, they may be

Pivot joints, admitting of rotation round a vertical axis, and through a frontal plane (horizontal plane) : example, superior radio-ulnar joint ; or

Hinge joints, permitting of flexion and extension round a frontal axis and through a sagittal plane : example, the inter-phalangeal joints.

Biaxial joints are joints allowing flexion and extension as well as abduction and adduction ; their construction often allows of a rolling but not a rotation movement. Such joints are found in the condyloid or saddle joints.

Polyaxial ball-and-socket joints allow movement in an indefinite number of axes and through all planes ; flexion, extension, abduction, adduction and rotation : example, humero-scapular joint.

Plane and gliding joints.—In the smaller joints simple gliding movements may take place in any direction, including some small amount of twisting ; but the actual amount of displacement is very small in extent : example, the vertebral, carpal and tarsal joints.

When movement is made, a skeletal adjustment comes about ; at least two bones have their relationship modified by the action of muscles. The proximal bone is regarded as fixed, while the distal bone is moved in the arc of a circle round its axis (or joint).

Ranges

Range of joint movement depends upon the degree of shortening of a muscle or group of muscles. Ranges are described as *full* when the two bones are moved to their fullest extent away or towards each other. A mid point or line bisecting these extreme points will indicate the middle of the range.

The middle range.—The middle line conveniently divides the full range into inner and outer halves.

The inner range is that half of the range when the working muscles are approximating their origins and insertions as closely as possible to each other.

The outer range is the other half of the range from the position of muscle-stretch to the middle line.

The diagram (Fig. 4) clearly indicates how the ranges of movement occur when the biceps contracts to its fullest extent.

Angles.—As the ranges alter, so there will be an alteration of the angle made by the fixed and moving bones. In assessing joint movements or disabilities it is essential to be able to calculate the angles through which movement takes place.

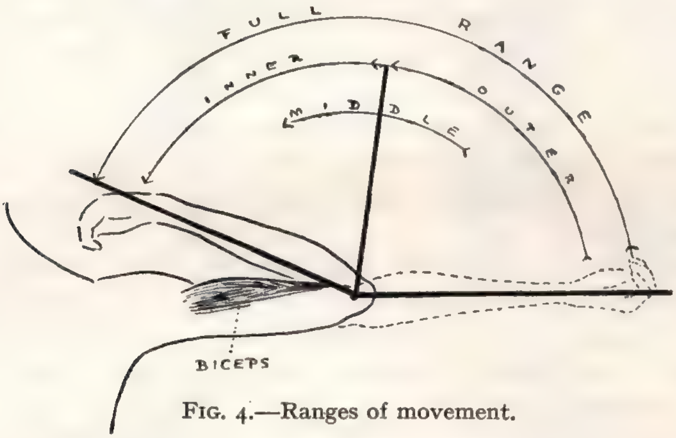


Fig. 4.—Ranges of movement.

Angle measurer.—Gross calculations can be made by the eye, and with practice some intermediate points can be fairly accurately guessed. But for accurate recording of results an angle measurer is absolutely essential, and there should be one in every physiotherapy department.

When assessing the disability of muscles, the range of each muscle has to be considered. In the diagram (Fig. 4) biceps is shown contracted in its shortest position and other parts of its range are marked out, while its antagonist muscle, triceps, is of course, in its most stretched position, that is, its outer range.

The restoration of function of joints and muscles is a major purpose of the treatments with which our work is concerned,

therefore for the preliminary examination of an injured limb the patient should be relaxed by one or more methods. The part of the body to be examined may be suspended (so that the limb lies in a horizontal plane, free from all obstructions to movement) or it can be examined in other positions.

The diagnosis and records having been studied, and the X-ray photographs examined :

(1) All visible changes are noted ;
(2) The necessary palpation of soft parts is carried out ;
(3) A comparison is made between the injured and uninjured limbs : first as to range and strength of voluntary movement, next of passive movement, finally of resisted movement. To determine the range of movement an angle-measurer (Fig. 5A) is indispensable.
(4) Muscle tests can be carried out as suggested in the chapter on Pulley Therapy.

Based on the result of this examination, appropriate schemes of treatment can then be worked out which cover the medical instructions.

Posture.—In all rehabilitation treatments good posture and a good carriage must be aimed at. Individual muscle treatment is not sufficient ; the body must be treated as a whole, and the effect of posture on the general health and the functioning of organs—such as the heart and lungs—must be considered as well as its *prophylactic* effect in the prevention of further complications, such as spinal trouble, flat foot, etc. It is only too easy to lose good posture through illness, long confinement to bed, and other causes. Hypotonic muscles do not respond quickly enough to the postural stimuli which are so sensitive in the healthy subject : the body has to be trained by remedial exercises frequently repeated to tone up the anti-gravity muscles and to re-establish the mechanism dulled by disuse, also to build up the muscle strength itself, so that the body weight can be maintained against gravity.

The line of gravity.—For equilibrium to be achieved, the line of gravity passing through the centre of gravity of the body must fall within the area of the base. The gymnastic definition of the base is " the area marked out by a line drawn round that

which supports the body." Thus, in the lying position the base is at its maximum ; in sitting position the area depends on the size of the stool ; whilst in standing it will depend on the distance between the two feet. However the feet are placed, equilibrium is poor in the upright position because of the smallness of the base.

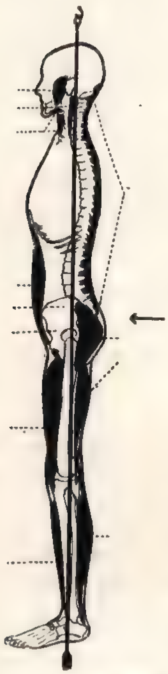


FIG. 5.—The line of gravity.

The dotted lines point out the chief anti-gravity muscles mentioned in the text.

Equilibrium in the standing position is also poor by reason of the high level of the centre of gravity * in relation to the base, and is maintained by constant interactions of the "anti-gravity" muscles. These are: extensors of hip, knee, ankle ; extensors and flexors of trunk ; splenius, middle half trapezius, latissimus dorsi ; abductor and adductor of the hips ; lateral flexors of the spine ; the retractors of the neck and the elevators of the jaw.

The line of gravity passes from the vertex, behind the ear, in front of the vertebral column (except in the cervical and lumbar regions), through the chief joints, and just in front of the ankle joint (Fig. 5).

Sir Arthur Keith states that lateral balance is also greatly assisted by the *thorax*, its *ribs and muscles*. "The thorax was transformed in shape *not* for respiration but for postural purposes . . . every muscle attached to a rib is a spinal balancer . . . every costal arc is made up of three segments, a dorsal to which the spinal muscles are attached, a lateral, acted on by the intercostals and oblique muscles, a vertical and anterior into which the rectus is inserted." †

Therefore good posture can only be maintained by the perfect

* *The centre of gravity*.—The centre of gravity of any object—including the human body—can best be determined by experiment. In the case of the human body, it will be necessary to lay the subject in the supine position, across the narrow edge of a boom or plank, while the correct anatomical position is being held.

The point at which the body will balance itself is the centre of gravity. This point will vary considerably in individuals (see arrow in Fig. 5).

† Sir A. Keith, *Man's Posture. Notes on its Evolution.* Chapter I of *The Injured Back and its Treatment.* J. Ellis.

co-ordination of all opposing muscle groups. The muscles concerned with posture receive constant stimuli from the semicircular canals, the eyes, the skin—especially that area which covers the soles of the feet—and last, but not least, from the constant stream of impulses which arise in the muscles themselves.

The muscular mechanism involved is that of the stretch-reflex. Each time a muscle is stretched, or a change of position is made, a fresh stimulus is received, a slight alteration in tension takes place, so that the muscles which maintain the balance of the body are at equivalent tensions. " All our voluntary movements take place on a background of general tonus. In diseased conditions where it is lost, the clumsy movements bear witness to the disability occasioned by its absence."*

As the active muscle fibres work in relay action, only a proportion of them are active at any moment. Thus we find alternate periods of rest and effort occurring in the body ; this time in groups of muscle fibres. We find in this the explanation of our ability to maintain posture for long periods without a sensation of fatigue.

Movement.—Voluntary movement is rarely confined to the simple movement of one part. Generally, an extremely complex sequence of adjustments is involved. Before movement begins, a certain tone resides in the active muscles and in the antagonist muscles ; as contraction of the active muscle proceeds the antagonistic group " pays out " just so much extension as the contraction calls for.

Other muscles responsible for the control of the joint at which the displacement is to occur must be braced sufficiently to keep the parts in contact. Often quite distant muscles must be toned up so as to maintain the required rigidity of the trunk or other parts, in order that the desired movement may take place smoothly and according to plan.

" Following Beevor, the muscles concerned in a voluntary muscular act may be classed in four groups :

(1) *Prime movers* (Agonists), those whose contraction is responsible for the movement of the part.

(2) *Antagonists*, those which oppose the prime movers.

* Starling's *Principles of Human Physiology*. 8th edition.

(3) *Synergists*, those which assist the agonist, and reduce unnecessary movement to a minimum.

(4) *Fixators*, those whose contraction causes the fixation of the neighbouring joints, and maintains the body or limb in a position appropriate for carrying out a particular movement.

" Normally these muscle-groups act as a unit. The contraction of the prime mover is accompanied by inhibition of the antagonist. . . . At the same time the fixator muscles of the neighbouring joints contract, thus enabling the prime mover to exert its force with a minimum of effort." *

The reflex mechanism.—As some of the central ideas in rehabilitation and re-education are concerned with the relaxation of muscle through *reciprocal innervation*, and others with the stimulation of muscle and other tissues through the *reflex mechanism*, a few remarks and quotations on applied physiology may not be amiss on this interesting subject. For this purpose some helpful accounts of how impulses are received and how they travel are taken from recent books.† These show us how the muscles of the body receive information, the result of which is well described by the term " muscle consciousness."

The central nervous system is a highly developed clearing-house, to which are passed countless messages from all parts of the body and from the centre of consciousness itself.

Incoming messages are delivered along the afferent nerve fibres ; outgoing messages along the efferent nerve fibres. The great bulk of the incoming messages refer to happenings in the environment of the body ; and it is therefore true to say that the vast majority of muscular movements, or adjustments actually made, are reflex actions.

The functional unit of the central nervous system is recognized to be the neurone, which consists essentially of two parts : viz., the nerve-cell body (neuro-cyton) and its branches, which are nerve fibres. The neurone doctrine assumes that there is no continuity whatever between the substance of one neurone and that of another.

* *Physiological Basis of Medical Practice.* Best and Taylor.

† Starling's *Physiology : Applied Anatomy and Kinesiology.* Bowen and McKenzie.

The neuroglia constitutes an all-pervading basic substance in which the various nerve elements are embedded in such a way that they are all bound together into a consistent mass and are yet all severally isolated and insulated from one another.

The neurone is furnished with one or more dendrons. The latter act as receivers of stimuli, which they pass on to the neuro-cyton; stimuli thus transmitted pass down the axis cylinder to the effector organ with which they terminate. Some cross the middle line, so that the opposite side of the body receives a stimulus and is thus kept "in sympathy." Some fibres or axons pass out horizontally into the lateral white columns; there they divide into ascending and descending vertical branches. Others ramify into different areas of the grey matter of the cord. The brain is also made aware of the sensory stimuli, as there is a relay station in the medulla, or even in the mid-brain. A synapse is defined as "a point of contact between one neuron and another." The synapses lie both vertically and horizontally, so that impulses started in the sensory side are carried to several fibres on the motor side of the arc. The synapses are susceptible to fatigue, while the nerve trunks themselves appear to be unfatiguable.

An interesting description of how a nerve impulse is thought to work is quoted: "The nerve impulse is a self-propagated disturbance. . . . Nervous conduction therefore depends upon the state of the fibre at successive points reached by the impulse. The impulse resembles a spark travelling along a train of gunpowder, rather than a wave transmitted passively through air and water. . . . To carry the analogy further, if a section of the powder-fuse is dampened in advance of the spark, the latter becomes less intense as it passes through the dampened section, and travels more slowly: upon reaching a succeeding dry portion, the spark flares up again to its previous intensity and velocity. . . . The flame of a match applied to the powder-fuse will start a travelling spark of no less intensity than one started by the flame of a torch. . . ." * From this it is argued that the nerve fibre gives a maximal response or none at all. "This 'all or none' principle also regulates muscle contraction. It is true that as the nerve-trunk is composed of many fibres, each of which supplies a group of muscle fibres, a

* Best and Taylor.

weak stimulus will contact only a proportion of the units of the nerve, while a maximum stimulus excites them all."

Reciprocal action.—When a muscle is stimulated into action by such a nerve impulse it will contract, but at the same time an equal and opposite response is felt in the antagonist. In this way movements are controlled, so that the acting muscles will not make jerky movements, for the antagonist muscle controls the action and it is smoothly executed. Thus it comes about that there is a *double innervation :* one concerned with contraction of the prime mover, and the other with relaxation or inhibition of its antagonist. It is thought that the inhibiting process may be due to a " cessation of the excitory impulses " which are at " normal " tone in a resting muscle, therefore the inhibited muscle has for the instant less tone than when it is normally at rest.

Application.—It is now evident that if a way of exercise can be arranged by which the prime mover only is brought under stimulation by repeated but rhythmical work, *two effects* will be produced by this one action : the prime mover will be stimulated and its tone increased, while the antagonist will be relaxed in a natural physiological manner.

In physiotherapy we are much concerned with the strengthening of muscles, but we are also often confronted with problems of spasm and contracture—where even one tight muscle can upset all proper voluntary movements in a limb.

For such cases the emphasis of treatment will then be on how *to manage* the spastic muscles so that they may be trained in relaxation by the continued action of stimuli which inhibit their contraction.

The reflex arc.—The involuntary muscular contraction which results from the stimulation of a sense organ is known as a reflex ; the controlling centre for this action is located in the spinal cord.

We are all familiar with the motor response to a painful sensation by the quick withdrawal of the part ; but reflex action also governs certain activities of the glands and the vascular, respiratory, and digestive organs.

The anatomical basis of the reflex arc consists of three parts :

(1) The receptor mechanism and its afferent, sensory nerve ;

(2) The centre (connector) in which messages from the receptor are analysed and passed on ; and
(3) The efferent nerve, bearing the instructions of the centre to the appropriate effector organ.

The effector organ may be a muscle or a gland ; but we are chiefly concerned with muscular and sensory responses, and confine our attention to receptors whose business is to stimulate muscles *into contraction*, or, as the case may be, to lower muscle tone by a *species of inhibition*. These receptors are responsible for our muscle consciousness or " muscle sense." By them we know and are made aware of our surroundings. The receptors can be divided into two groups :

(1) Those which receive impressions from the outer world. These are called *exteroceptors*.
(2) Those which are concerned with the inner workings of the body. These are called *interoceptors*.

The *exteroceptors* are subdivided into—

(*a*) Telereceptors (vision, hearing) ;
(*b*) Chemical receptors (taste, smell) ; and
(*c*) Cutaneous receptors.

The last are classed according to their function ; some attend chiefly to circumstances likely to cause us injury, and are carried as pain impulses. The chief cutaneous receptors are the hair follicle, Meissner's corpuscle, and the Pacinian corpuscle, all sensitive to touch and pressure ; and the Krause end-bulb and Ruffini organ, sensitive to cold and warmth respectively.

The *interoceptors* receive impulses from within the body. They are also subdivided into :

" (*a*) Proprioceptors, which note movements or record the position of parts of the body ; these are situated in muscles, tendons and joints.
(*b*) Visceroceptors, which pass on numerous messages concerning the internal organs."

Details of the proprioceptors.—The receptors with which physical methods of treatment are primarily concerned are the kinæsthetic

or muscle proprioceptors, which are chiefly represented by the muscle spindles. In these structures a specialized type of muscle fibre receives three nerve elements.

"(1) One is an afferent nerve fibre which, after penetrating the sarcolemma and losing its own neurilemma and medullary sheath, is spirally wrapped round the muscle fibres, the whole structure being enclosed within a capsule.

(2) Usually a second afferent fibre enters the capsule and forms dendritic branchings on the surface of the modified muscle fibres.

(3) The spindle fibres also receive motor fibres with the usual *motor end-plates.* The *muscle spindles are regarded as stretch receptors;* these are excited when the muscle is *elongated passively.*" *

The *tendon receptors* are represented by the Golgi tendon nerve-endings, which are found in the tendon near to its attachment to the muscle fibre. These are sensitive to tension, but since they are placed beyond the end of the muscle fibre they will respond to a pull of any kind on the tendon, whether due to passive stretch or to an actual contraction of the muscle; therefore they are called *tension receptors.*

In addition to the above, receptors of other kinds will also be brought into play whenever movement occurs or posture is modified. "The cerebellum is concerned mainly with voluntary movement: it is the chief assistant of the higher centres. It must be in communication with the labyrinth and muscle proprioceptors, and be informed of the intentions of the cortex. It is probably through the cerebello-rubro-spinal pathway that the cerebellum exerts its chief synergizing action upon muscles, adjusting their tone appropriately as to time, strength and distribution to the voluntary discharge." *

The responses of skin and muscle receptors.—The impulses which pass down the nerve fibres are revealed by the brief "action currents" which they produce. It is found that when non-polarizable electrodes are placed on a mixed nerve of an animal *at rest,* a continuous stream of action currents can be recorded.

* Best and Taylor.

These impulses of the resting nerve are of low frequency—from 3 to 5 per second in each fibre. They arise from the proprioceports of muscle and tendon, and the frequency is increased when the muscle is stretched.

Many members of the Chartered Society will remember a very fascinating lecture at one of our congresses, when Professor Adrian actually demonstrated "action currents" on a living model. The amplifier was used to enable muscle actions to be heard. Methods of this kind have shown the responses of skin and muscle to stimuli. The results are as follows:

(1) *Passive movement* causes a prompt *rise* in the impulse frequency.
(2) *Light pressure on the skin* causes a rise of frequency as a result of the stimulation to the skin receptors.

Tension on the tendons.—Tendons are influenced by tension, again either passively applied or by active contraction.

Passive stretching.—Passive stretching is an adequate stimulus to the muscle spindle element, provided it is carried out at a sufficiently rapid rate. The spiral fibres are stimulated by both passive stretch and active movements. The behaviour to active contraction is distinct.

Application: Muscle consciousness.—It is by these means that the instinct called "muscle consciousness" arises, and our reflex system, with cerebellar control, allows awareness of every change in temperature, every joint and muscle movement or manifestation of pain. Thus the body is able to make instant adjustments to safety or comfort as the case may be.

Surely it is also in this way that physiotherapy (heat, massage, hydrotherapy and exercises of every description) must make its effects felt *upon the exteroceptors.* The ultimate result or combination of such processes result in a stimulation of the reflex mechanism by the simple application of touch, heat, bending, stretching and voluntary movement. Dr. P. Bauwens* has worked on these matters in relation to the treatment of muscles by graduated faradic current, he states that "The *tone* in skeletal muscles is largely controlled by afferent impulses originating *in the muscle*

* *C.S.P. Journal,* May, 1936.

sense organs themselves, but other impulses of peripheral or central origin can influence them. Stimulation of the sensory organs in the extensor muscles by compression or by stretching initiates a two-fold reaction in the cord. The tension in the extensor is augmented, while the tonic impulses to the flexor (which is an antagonistic muscle) are decreased. This important mechanism comes into play in the stretch reflex, and also in voluntary movement." Further investigation into the physiological basis of physical treatments is much needed, so that our work can be put on a more sure basis.

In an attempt to make use of these physiological factors in a practical way, various methods of treatment are suggested: for instance, the use of traction and passive stretching of joints *combined* with massage should give a more effective treatment than each single treatment does alone. The stimulation of the reflexes through stretch and contraction applied in constant rhythmic movement would appear to be sound tactics on the theoretical side, and is *in fact* a very useful form of therapy.

Stanley Cox & Co.

FIG. 5A.—Angle Measurer

This is a precision angle measurer which can be used either under or over joints. The scale is graduated up to 180°. The instrument folds flat when not in use.

Chapter III

APPARATUS FOR RE-EDUCATION AND REHABILITATION

Some principles of mechanics are of importance in physiotherapy, and are concerned in every application of force and energy. In working out the design of new apparatus and the various methods of exercise, the writer has tried to demonstrate this fact. Simple devices are suggested which give varying amounts of mechanical advantage to the operator over the patient, and also to the patient over the forces which tend to oppose movement.

The actual processes of rehabilitation as described will be better understood if some fundamental mechanical principles involved are appreciated. In order to get the fullest benefit from the use of apparatus its physical properties should be investigated ; even such simple things as pulleys and springs have specific and independent functions in connection with self-activated exercise.

Suspension apparatus is used to obtain as perfect a position as possible with regard to equilibrium, and the counterpoising of the body against gravity for the treatment of suitable cases. This subject is most ably discussed by Dickson Wright, M.S., F.R.C.S., in a following chapter.

A framework from which to suspend the body and a collection of springs and pulleys are all the apparatus which is required. By means of these, self-activated exercise or weightless movement can be arranged for patients, while the physiotherapists' work can be extended without increasing their fatigue.

All apparatus should be constructed so that it is as strong and serviceable as possible ; it will then last for years, even with the wear and tear of an out-patient's department. Rope of good quality and a strong canvas belt can be relied upon to give long life, if they are made by firms accustomed to supplying ship's gear. The framework from which the suspension itself is carried out must be stable ; the apparatus shown in Fig. 6 called " Standard," is a strong, well-made article. The design has been

carefully thought out so that it can be used either for ward cases for use over a single bed, or as a *portable gymnasium* where more than one patient can be treated at a time (see " Pulley Therapy ").

"Standard" apparatus.—The illustration shows very clearly the general aspect of the apparatus and the more important details.

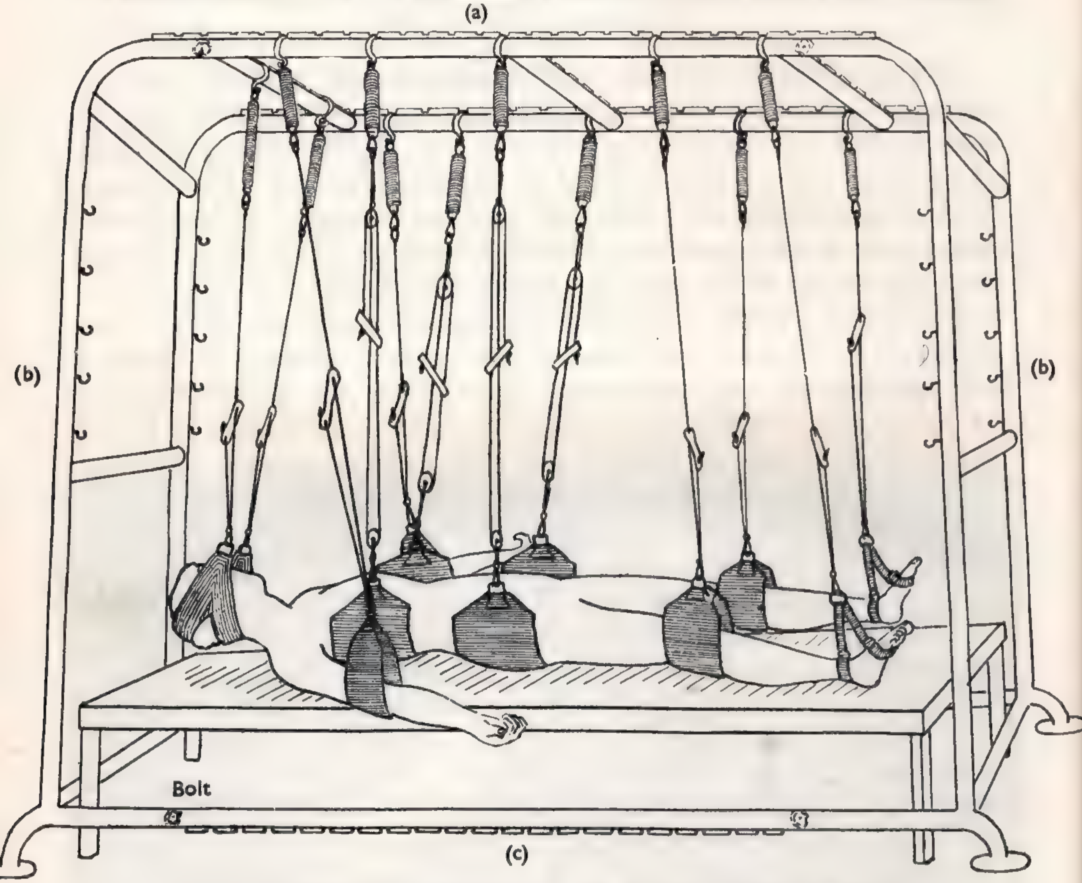


FIG. 6.—Relaxation in suspension ; also an instructional diagram.*

When a human body or a part of it is supported on springs, slings, and pulleys, we are concerned with an example in statics, the combination of the weight and the other forces applied producing a condition of rest.

The frame is in form somewhat pyramidal, and is constructed of light-gauge steel tubing of $1\frac{1}{2}$ in. diameter. It is made in five

* The ropes are vertical and support the body at the centre of gravity of each area.

parts, viz. : (*a*) the top (roof-unit), (*b*) two side units, and (*c*) two loose bars which unite the latter near the feet. There are thus but eight connections to be made, which are secured by eight tapered bolts and their nuts ; the position of these are shown in Fig. 6.

The standard dimensions are :

Height	7 ft. 0 in.
Length	8 ft. 0 in.
Width at base . . .	3 ft. 6 in.
Width at top	2 ft. 0 in.

The dimensions given are recommended where the apparatus is to be used in the gymnasium for strenuous exercise or for group exercises. (For an individual patient $1\frac{1}{4}$-in. steel tubing would make an adequate framework.)

The feet are of large diameter, to avoid damage to floor surfaces.

The long top and bottom rails are notched to provide positive anchorage for sling suspension and fixation. Two extra cross-bars made to slot in the roof section are very useful. (They are not shown in the diagram.) The uprights are provided with hooks for various attachments needed in some of the exercises.

The general dimensions are such as to allow the introduction within the framework of a bed or plinth on which the patient is to lie. The height is selected in accordance with experience, as being that most suited to the treatments ; a clearance of about five feet is given, which is sufficient to avoid jamming of the suspension cords or their mutual interference, but a greater height allows too much swing to be set up and all fine work is lost.

The belts are of strong canvas, bound and shaped and finished in a ring for easy attachment to the clips on the cords. All cords are arranged to be easily moved and are interchangeable, so that they can be hooked to a common hook or in separate places on the non-slip top-rail, as may be required.

The ropes are of stout cotton. One end is finished with a ring for hanging to the notched top-rail or to the suspension-springs, as the case may be. The rope passes twice through a wooden cleat, and carries in the bight a galvanized steel clip for attachment to the slings ; but in the case of the slings required for lifting the shoulder and pelvic regions a modified type is used, which in-

corporates two pulleys arranged to cut down the load to one-half. The use of the cleats is similar to that employed in setting up a bell-tent, and is found to be a quick and simple means of fixation.

For suspending hands and feet, use is also made of a stitched canvas belt, having a ring at each end and carrying a free ring to receive the clip of the suspension-rope.* The method of use can be learnt from the diagrams more easily than can be expressed in words.

For the limbs, the two ends of the canvas sling are brought together for suspension by a single rope. For pelvis and thorax the two ends of the sling are given separate ropes (each of which is of the special type described above).

The head is given a special cap or sling, which requires a rope to each end and a spring strong enough to support the head, though not so strong as not to yield to comfortable pressure. This method of suspension serves the two purposes of affording comfort, when the head is not itself under treatment, and of providing suitable resistance for the exercise of the various muscle groups that activate the head.

For the body in total suspension, slightly different arrangements are used according as the patient is in a supine position or on the side. In both cases the broad slings are used at pelvis and thorax. When energetic work is to be done, shoulder and perineal straps must be used to keep them in place ; limbs require four separate slings ; the head, the special cap as described. In the case of side-lying, slings are used at head, thorax, hips, thighs and ankles ; both legs being supported in a single sling at each of the two last points.

In the case of such total suspension :

(1) The plinth should be placed under the framework so that it is covered by the apparatus.

(2) The belts having been arranged at appropriate intervals along the plinth, the patient should lie down on them.

(3) The head-cap (sling) is next adjusted and raised to a comfortable height.

(4) Feet and thighs are next raised about four inches from the couch.

* Self-adjusting strap or three-ring belt.

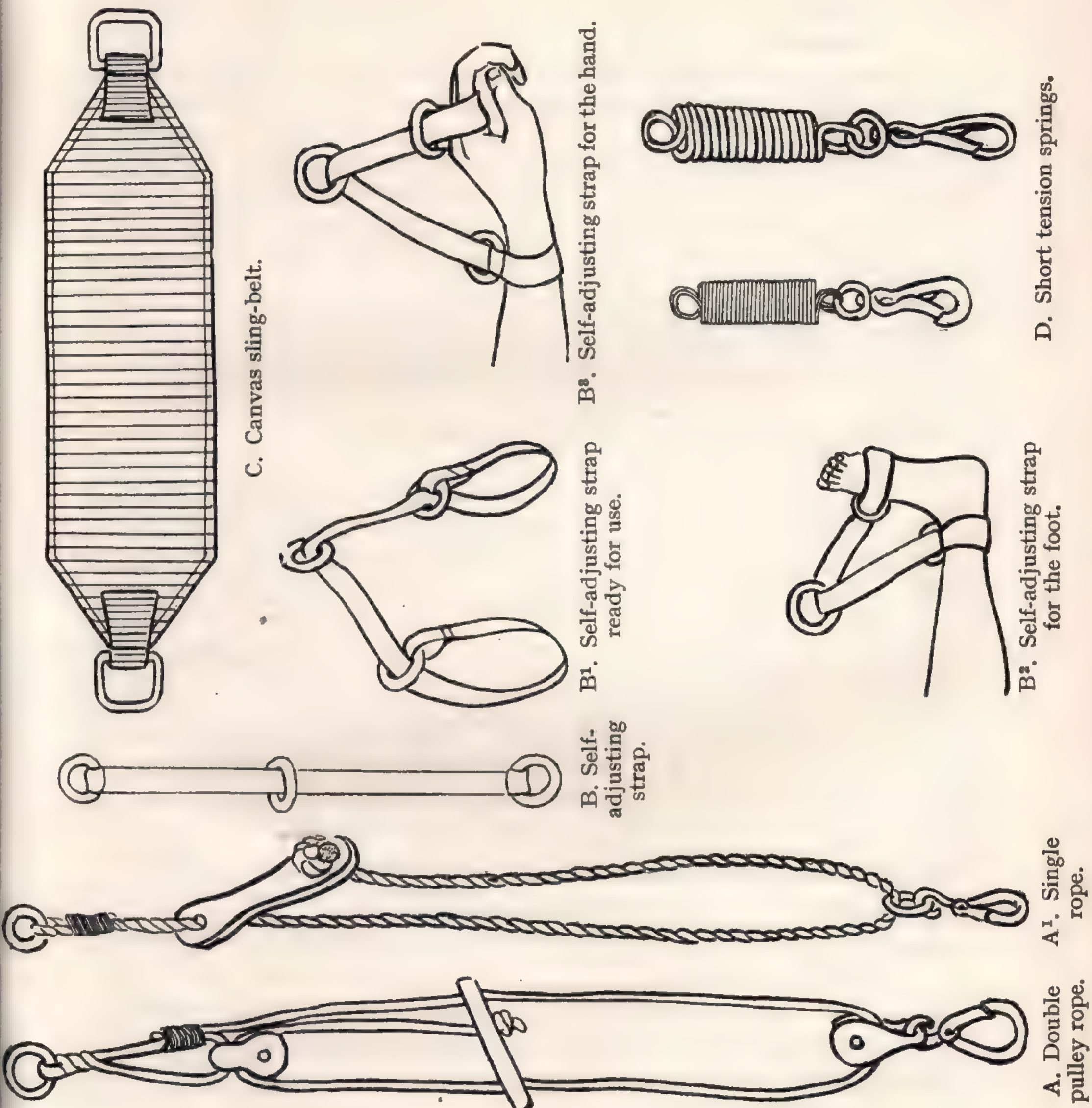


FIG. 7, A to D.—Suspension gear.

(5) The thoracic belt can then be raised by stages, also the two arms; the head may then be raised a little higher for comfort.

(6) Finally, the pelvis should be raised until the patient can swing clear of all obstructions.

For a heavy patient, it may be necessary to employ additional slings at the waist or thigh; extra slings should be always at hand.

If the patient is helpless, one end of each belt can be passed under waist, neck and popliteal spaces; the belts can then be arranged in the correct positions.

A large radiant-heat lamp will add greatly to the patient's comfort during suspension exercises. Long, warm bed-socks are advocated for the warded patient.

Anchorage.—By means of half-suspension (one-half of the body being left in contact with the plinth) a fixed initial position is provided, from which many treatments and tests can be performed. If, for example, head and shoulders are so fixed, the abdomen, pelvis and legs can be isolated. Alternatively, if the lower half of the body is fixed, the shoulder and thorax can be freed for treatment (Fig. 20).

In case of suspension of a limb, it is important, when two ropes are in use, to see that both are supported from the same point and at the centre of gravity of the limb. Even where only one arm is under treatment, it is advantageous to support both arms on account of the balanced feeling this causes; and, of course, the same is true of the lower limbs (Fig. 104).

Suspension apparatus is used for three major purposes:

(1) To assist the incapacitated patient.

(2) To obtain fine grading of exercise for the after-treatment of recent injuries.

(3) To obtain leverage and fixed points for the manipulation or correction of certain orthopædic conditions.

Spring-suspension adds to the above—

(4) Buoyant movement
(5) Oscillatory movement } if hung vertically.

(6) Resistance movement if hung vertically, laterally. or below the patient.

All these have their special purposes.

Makeshift apparatus.—A practical makeshift apparatus can be made by the use of two parallel bars (or gymnasium booms) placed at a distance of 2 feet apart, and at a height of about 7 ft. 6 in. from the ground. With this arrangement a steady and quite satisfactory overhead support is obtained, and moreover one which can accommodate two or three patients at the same time. Some care is required to prevent any slipping of the ropes along the bars.

For ward cases, it is necessary to make use of the existing devices called *Balkan beams*. These structures vary in the different hospitals. The most satisfactory ones are made of stout pinewood, securely fastened to the framework of the bed. They should be fitted with cross pieces notched to prevent the ropes slipping.

SPRINGS FOR BUOYANT SUSPENSION

Short tension springs and their special uses.—The type of suspension apparatus hitherto described restricts motion in its simplest form, *i.e.* in a single horizontal plane about a single axis. If we now introduce spring suspension, more or less movement will occur in planes at right angles to the horizontal ; the amount of movement depending on the type of spring and the properties peculiar to springs. The springs employed for the purposes explained below are usually of short initial length, so as to provide for a small range of movement, and are of various tensions, according to the functions they have to perform. For simple suspension, as for relaxation purposes, short springs are used of three strengths, selected by their tension to support the weight of the various parts of body.

For hands and feet . . .	Light tension springs.
For head, thigh, and upper arm .	Medium ,, ,,
For thorax and pelvis . . .	Strong ,, ,,

When short springs are included in the suspension outfit, the entire body can be accommodated in comfort and an immediate sense of buoyancy prevails. Pressure is removed from all soft parts of the body and the general sense imparted to the patient is that of floating on air or in a *buoyant medium*. All limbs are entirely unimpeded for movements in a horizontal plane, whilst

the spring suspension admits also of small vertical movements. General rhythmic movements, when undertaken with minimal or maximal effort, afford a sense of exhilaration, which in many cases is itself of no little therapeutic value ; and it is difficult to describe if not experienced.

Relaxation.—Suspension in the supine position is found very greatly to assist in inducing relaxation. Total relaxation with the patient supported on short springs is sometimes, and for some cases, more advantageous than simple suspension, as it is a more comfortable position.

Resistance.—The short springs are also used for resistance movements involving very short ranges of movement, such as when exercising the neck muscles. These springs must on no account be strained, they are *not* suitable for real resistance work.

Co-ordination.—Suspension of the whole body is also used when it is desirable for a patient to undertake simple or complex co-ordinated movements.

Shock-absorbers.—Another useful employment of short 4-in. springs is as shock-absorbers. These shock-absorbers have been used when treating paralysis with sensory loss as their use greatly relieves pressure at the various points of suspension.

To summarize ; *short springs* are used as follows :

(1) To give buoyancy to movement ; to encourage rhythm in movement.
(2) To assist relaxation.
(3) As resistance for *short* ranges of movement only.
(4) To promote co-ordination of movement.
(5) To increase comfort and act as shock-absorbers.
(6) To take up slack in a rope when two belts are in use, and one does not fit comfortably.

REHABILITATION SPRINGS AND THEIR USES

Long-spiral springs.—" Helical " (from the Greek *helix* : a spiral).

All gymnasts will be familiar with the springs that are found on sports training outfits, such as the sculling exerciser outfit, or with the expander devices made by many firms. Springs have always

been understood to be good for resistance exercises and have an undoubted value in that capacity ; but the author has found that there are other ways of using these springs. These uses are based on an investigation into the physical properties of such springs. These properties make them peculiarly suitable for employment in remedial gymnastics.

(A) They are capable of producing oscillatory movement, and they make an ideal suspension medium by which to balance out gravity.

(B) By their kinetic recoil they can be used to assist muscle work against gravity or for purposes of giving traction.*

(C) They are used as variable resistances to build up muscle strength.

From a practical point of view they offer many advantages. They are portable, easily fixed into position, and take up relatively little space, even when the patient is in action—a most important consideration in most hospital departments or for the treatment of ward cases.

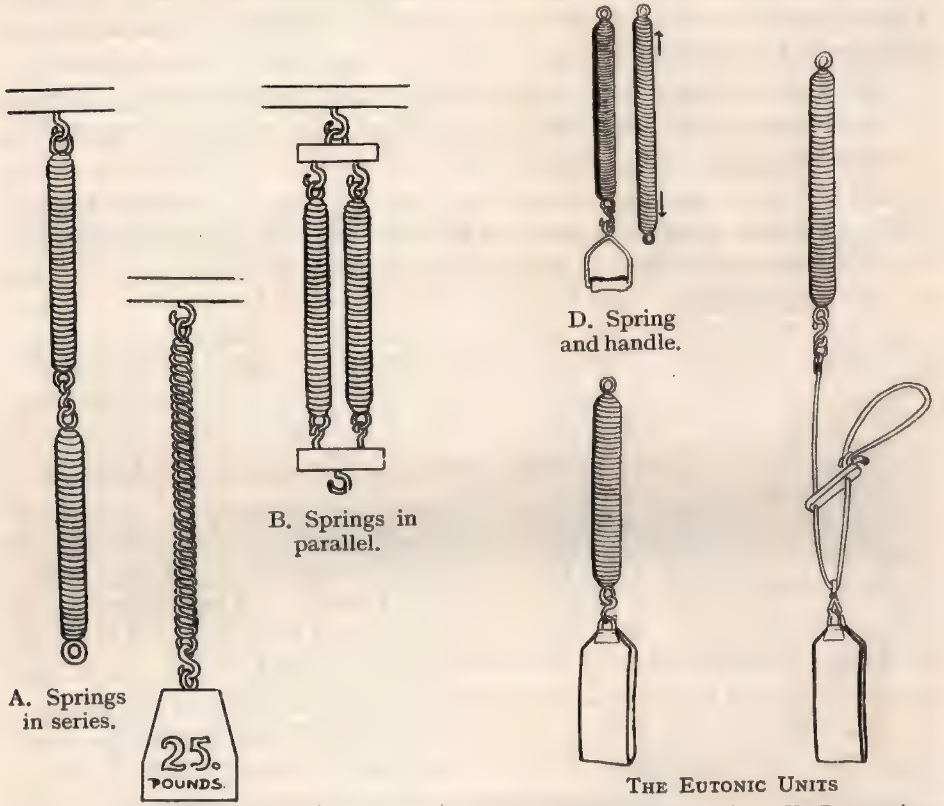
If a spring is rigged with an adjustable rope and strong canvas sling (Fig. 8, D, E and F) it will be easy to " set up " any desired exercise for resistance or other work. The range of the joint movement can be controlled by altering the length of the rope in relation to the orbit of the moving limb, thus short ranges and inner paths can be selected for muscle development work if desired. In this way the spring is also safeguarded and need never be overstretched and damaged.

Analysis of the physical properties of helical springs.—The strength of a spring, by which is meant the resistance to extension, varies with the diameter of the wire of which the spring is made, the number of coils and the mean diameter of the coils.

" *Strength.*"—To be more explicit, by the " strength " of a spring is meant the force it opposes when in equilibrium to extension or, as the case may be, to compression.

* When a mass is in motion it is said to possess " kinetic energy." Masses which are not actually moving, but are capable of being set in motion because of their condition, are said to possess " potential energy." Thus an extended or compressed spring or displaced pendulum has potential energy. If a mass (*e.g.* a human limb) is connected to the spring and an oscillatory motion produced, during the movement the mass has kinetic energy which is continually being converted into potential energy as the spring is extended or compressed.

Springs in series.—If, therefore, use is made of a standard type of spring we can reduce the " strength " by employing two or more springs *in series* (see diagram (Fig. 8, A)).



A. Springs in series.

B. Springs in parallel.

C. Spring on tension with weight.

D. Spring and handle.

THE EUTONIC UNITS

E. Short sling-spring arrangement.

F. Long sling-spring arrangement.

FIG. 8, A to F.—Practical units for rehabilitation exercises.

D, E, F.—The spring is only part of the suspension outfit; the adjustable rope allows of many variations in exercise. This arrangement of spring-rope and sling is called the *Eutonic Unit* (Greek: Eu=*best*; tonic=*tone*). (See p. 162.)

Springs in parallel (see diagram (Fig. 8, B)).—If it is necessary to retain the standard range whilst increasing the strength of the spring force, this is achieved by employing two or more springs in parallel. THUS STRENGTH AND RANGE ARE INVERSELY PRO-

PORTIONAL. If we double the range by employing two equal springs in series we halve the strength.

Deformation or deflection.—There is a limit to which the extension of a spring may be pushed before permanent deformation occurs, *i.e.* the amount of safe extension. This is also defined as " the range " of the spring. A safety device or cord is usually inserted in the coil.

An accumulator.—A spring is also employed as an *accumulator of energy*, the amount of energy stored being directly proportional to the extension given to it.

The springs used for these exercises are *calibrated by poundage.* The poundages quoted for the " standard " springs are the pressures exerted when the springs are *extended to their fullest extent;* therefore the springs are called 10-lb., 30-lb., 50-lb., etc. They measure 14 in. in length with a diameter of about 1 to 2 in.

Suspension from long springs gives us further advantages of movement through multiple axes and planes. The energy of the long spring on its recoil speeds up exercise to a remarkable degree, so that much activity is possible in a relatively little time. The sling offers comfortable support during rest-periods.

In our work it is necessary to handle apparatus which is convenient and which can be adapted to varied purposes. A combination of sling-suspension with helical springs gives us many useful variations of exercise.

We can make use, in particular, of:

The *ease with which* the spring *may be adjusted* to requirements.

The *compensating property* by which a spring's strength adjusts itself to the force applied.

A. TO SET UP AN OSCILLATORY SYSTEM *

If a heavy object is allowed to hang from a spring which is attached to an overhead beam, the spring will be stretched under the influence of the force of gravity acting on the mass of the object until the " weight " of the object is exactly compensated by the strength of the extended spring. That is the point of equilibrium. If instead of placing the object at that point we allow it to *fall* there, its momentum acquired in the course of falling will cause it to extend the spring beyond the normal compensating point; the strength of the spring will more than suffice to balance the weight of the object, whose downward movement will be first checked, and stopped, and then reversed. The object will now acquire an upward movement, which will carry it beyond the point of equilibrium where the reduced strength of the spring will not suffice to hold it; it will again fall, and the phenomena will be repeated. We have here what is called an oscillatory or vibratory system, complete with a natural " frequency " and " amplitude " of movement. The vibratory motion once set up will continue for a very long time.

If now, instead of leaving the system to come to rest, we apply occasionally, or with every vibration, a small external force slightly larger than would be needed merely to maintain the vibrations at the range first set up—either, that is to say, assisting gravity in the downwards vibration or assisting the spring in the upwards vibration—it will be seen that the range will be gradually extended, thanks to the accumulative property in the spring and the load. We are thus able, by repeated applications of a small force, to induce in the system an oscillation which, if to be generated by a single application, would require a large force.

B. SPRING ASSISTANCE

The use of an oscillatory system for remedial exercises.— The vibratory motions which occur when a free weight is hung on a spring can be made use of for remedial exercises. In the

* A simple experiment with a spring and weight will demonstrate these facts immediately (Fig. 8, C). Such a system (mass-spring) has a natural free period and frequency of oscillation or vibration.

case of a human body we are no longer dealing with a free weight, but with a limb which is attached to a joint. The movement is still oscillatory, with a certain, though limited, frequency and amplitude of movement; the oscillations are, however, immediately influenced by any muscle activity of the patient, who can either stop the movement, augment it, or keep in resonance with the spring's movements. The limb will move in the segment of a circle in the vertical plane, and about the fixed point which supports it in equilibrium.

Resonance.—If the patient's movements are kept in time with the oscillatory movement of the spring system, then they are said to be "*in resonance*" The movement will require the *least* muscle effort when the impulses are thus timed.

C. RHYTHMICAL-RECOIL "ASSISTANCE"

The kinetic recoil of a long steel spring can also be made use of for further remedial purposes.

(1) One of the chief uses is to assist muscles to lift the body-weight against gravity (pages 152 onwards).

(2) Another use is to provide a means of giving "traction to joints." This is called kinetic traction, and distinguishes this type of exercise from static traction.

All the exercises already discussed make use of the *natural frequencies* of the systems in which the suspension is arranged. The moment any departure is made from that plan. the exercises take on an entirely different character. Whereas, hitherto the effort required of the patient has been minimal, if he now *opposes* or in any way interferes with the natural frequencies he will encounter the full potential energy locked up in the moving parts of the spring-system: the exercises change their character and are concerned with muscle-strengthening work, *i.e. resistance exercises*. It should always be remembered that muscles work best when they work against resistances.

D. SPRING RESISTANCE

Helical springs under load will extend with increasing resistance until the force opposed is equal to the force applied.

In this way they are used to restore full power to muscles by exercise.

Resistance exercises can be arranged so as to act against any muscle-group. The position of the spring in regard to the body may be in any direction. For illustrations see "Eutonic Exercises." (Figs. 72–77.)

(1) If hung above the recumbent patient the resistance is available for the hamstring muscles, adductors of arm, head, and back extensor muscles.

(2) If hung above and behind the patient the extensors of the hip joint can be activated in "thrusting movements." Thus, many of the anti-gravity muscles can be kept in condition while the patient is still confined to bed. A great variety of natural movements can be carried out, as the apparatus is very adaptable.

(3) For nerve injuries, springs of *unequal strength* should be used bilaterally, in this way the weak side can be kept moving in unison with the "good" side.

(4) With *suspension* discarded, and the patient up and walking, resistance is applied above, below, or lateral to the sitting or standing subject, as shown in the diagrams of *regional exercises.*

(5) *Spring-resistance* can be increased by a parallel arrangement of similar springs.

(6) *Muscle-work* can be arranged so as to co-ordinate groups of muscles in resisted actions. One limb or four can be put into action at the same time. (Figs. 169–170).

(7) *Group-treatments* can be arranged so that the patients with *similar disabilities* can work in competition with one another ; they can be easily supervised if carefully thought-out starting positions are chosen.

Alternatively, a group of patients, *differing in their disabilities,* can be arranged to carry out individual exercises while under supervision.

PULLEY APPARATUS

Definition of pulley.—A pulley consists of a small grooved wheel fastened by a pin or axis into a block.

Types of pulleys.—There are various types of pulleys. Some are fixed to a type of bracket which can be screwed into a wall or ceiling laterally or vertically. These pulleys have only one direction of movement and care must be taken to see that the patient does not chafe the rope during treatment. Most standard types have a compensating device which allows of movement in two planes. A pulley block, such as is used in a ship or boat, has a wooden block and is fastened with a rope strop; this allows the pulley to be tied *loosely* to a beam or bracket, and

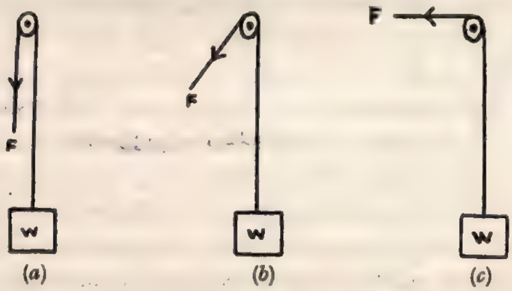


FIG. 9.

There is more friction at pulley (*a*) than at either (*b*) or (*c*), but the friction with a good pulley is very small as the parts roll on each other and do not rub.

in this way a compensating movement is obtained which makes a cheap substitute for the more elaborate standard units with swivelling pulleys.

Functions of pulleys.

(1) To change direction of force.
(2) To modify the effect of force.
(3) To obtain a mechanical advantage.

The device of the rope and pulley is very adaptable, being sometimes rigged so that its use is merely to modify the direction of force, sometimes to modify in addition the effect of the force.

Thus, with a single pulley fixed below a beam, and a rope passing over it attached to a weight at one end (Fig. 9), it is clear

that the weight will rise as much as the hand pulling at the free end is moved in the line of the pull (whether vertically or in some other direction), and there is *no* mechanical advantage, but there is an alteration of the direction of the force, and the friction varies with the angle of pull.

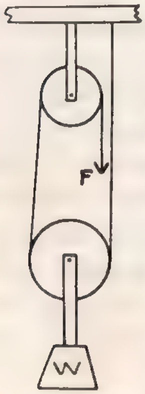


Fig. 10.—Mechanical advantage is obtained by the use of two pulleys.

To obtain a mechanical advantage, see Fig. 10.

If one end of the rope be made fast to the beam, and then passes round two pulleys below which hangs the weight, it will be seen that a pull on the free end of the rope will raise the weight a distance that will be *less* than the distance through which the pull takes place. If the downward pull is vertical the length of the pull will be just twice the distance the weight is raised, and the force of one-half the weight, neglecting friction, will suffice to balance the latter. This arrangement is made use of in the Standard suspension apparatus in order to gain a mechanical advantage when lifting a heavy patient: a two to one advantage is secured by the particular method of lifting (see Fig. 6 of "Full Suspension").

In remedial work pulleys and weights give a system of fixed-value-resistance. The therapeutic uses of weight and pulley will be found on page 137 onwards.

CHAPTER IV

PRINCIPLES OF SUSPENSION EXERCISES

To assist early self-activated movement in patients at the earliest stages of their disability it is necessary to try to understand the difficulties against which they have to contend. Gravitational forces have to be overcome, as they always oppose movement. The psychological aspect has already been touched upon, but there still remains the *gymnastic* aspect. The physiotherapist must so arrange the work that all movement is reduced to its simplest form. This simplicity serves two purposes: (1) the required movement is more easily understood by the patient, for by simple suspension, movement is confined to *one plane* and *one axis*. (2) This analysis of movement into a single plane and axis assists the operator to control the range of movement, to palpate the tendon of the working muscles, to detect fatigue, and to correct incorrect muscle-work if the need arises.

FIG. 11.—Diagram of 10-stone body showing weights in lbs. of head, trunk and limbs. After Mensendieck.

Weight is a force due to gravitation, the earth attracting all bodies to itself with a force proportional to their masses.

Mechanical opposition to movement and its solution.—Any enfeebled patient who lies helpless in bed, from whatever cause—be it surgical interference, recent injury, paralysis, or a painful joint—is hampered by certain mechanical forces when movement is required of him. His limbs are too heavy for his weakened muscles. On analysis it is found that these impediments are of several classes, yet all act by opposing movement, and are therefore mechanical obstructions to movement. These forces are experienced as weight, friction and internal resistance.

Gravity.—In health we are usually unconscious of the action of gravity on our bodies, and only become aware of it when conscious

of the sensation of fatigue due to the effort to overcome it, as when climbing a hill, or engaged in similar strenuous occupations. We are totally unaware, even in ill-health, of the immense pressure to which our bodies are continually subjected, owing to the weight of the atmosphere—15 lb. per square inch. So massive and efficient are the muscles of a fit person that he has no natural conception of the considerable weight of the various parts of the body; but that they offer serious resistance to movement becomes only too apparent in every type of disability where *loss of function* is the common denominator.

Therefore, to assist the patient we must enable the body to come to terms with the force of gravity. The centre of gravity must be brought as low as possible to the base, and the body must *rest in equilibrium on a fixed support*, or *hang from a fixed point.*

Friction.—When a limb is moved by muscular effort it is either hanging at the side of the body or lying on the bed; in the latter case, frictional resistance is never a small matter, and it may be a very large force. If we transfer the limb to a horizontal, highly polished surface, the resistance is cut down to a small force, though in practice it is still a measurable amount; but if we suspend a limb, by means of a sling and rope, and attach it vertically over the axis of movement of the joint to be moved, *friction will be eliminated.*

In addition to friction and gravity there are internal forces which may also oppose movement, these are:

A general tensing of the body through fear, due to physical and mental conditions.

The natural subconscious guarding movements set up in opponent muscles, if pain is likely to occur on movement of the prime movers.

Any undue fixation actions of muscles controlling the joint.

These forces, which we may term *internal resistance*, can be controlled by relaxation, adequate support, and, above all, by the patient's active co-operation through self-activated movement. Such relaxation and support is a marked feature obtainable by the simple expedient of suspending the injured part.

The necessity for weightless movement.—In order to compensate the patient against the forces of gravity and friction, it is obvious that some type of framework is necessary from which to suspend the various parts of the body under treatment.

When suspended a limb will swing freely about its axis at the lightest touch ; the joint fixator muscles do not go into spasm if the joint is securely supported, and the gentle rhythm of the swing is quickly understood by the patient and appreciated. In this way fear is overcome.

The apparatus suggested in this book is designed to cover all possible eventualities. It enables a feeble patient to carry out self-activated movements, at the earliest possible stages of his recovery ; as the effort, though active, is *minimal*, and the movements *weightless*.

The need for early movement is physiological, and the need to transfer the responsibility to the patient is psychological. In an ideal treatment, it should be possible to combine and fulfil both these requirements.

Types of exercise available in suspension are : (1) passive ; (2) weightless active ; (3) assisted ; (4) graded resisted.

(1) **Relaxed passive movement in suspension-slings** are usually contra-indicated for orthopædic cases, but they are absolutely essential for other cases ; for instance, where the muscle-sense has been lost through cerebral injury, or through long disuse of certain muscle-groups, it is then very difficult for the patient to isolate mentally the will-power required to call into play the muscles undergoing a course of re-education and *only* those muscles. The limb having been suspended appropriately, and the movement initiated by the operator, the muscles under treatment are alternately extended and relaxed without the volition of the patient ; the latter then begins to apprehend what is required ; the idea of movement is kept up ; and the cortical functions are stimulated.

(2) **Weightless active movement.**—Though differing widely in their pathology, most cases of joint stiffness will react to the principles underlying weightless active exercise. A feeling of absolute support must be given, and the apparatus must be strong and well adjusted for the purpose.

For joint treatments, such exercises in suspension will allow *minimal activity* of the weak muscles, at the same time a *reciprocal-relaxation* is obtained in the tightened and spastic antagonist muscle group. A wide range of active movement can easily be given in the horizontal plane. The faintest return of power is allowed free play, the activity of the muscle contributes to more rapid recovery, and the patient, persuaded by the ease and range of movement into thinking that he is accomplishing more than is actually the case, is encouraged to exert every effort without the usual fear of pain ; as movement is self-controlled the restoration to normal function is hastened. For limb treatments bilateral suspension is strongly advocated as it promotes a feeling of security and balance and aids co-ordination.

Relaxation is the essential preliminary to this method ; limbs should be hung from the support, passive then active movements can be given, so as to obtain the fullest ranges of which the joints are capable. The exercises are uniaxial and aim at mobility in one plane only at one time.

(3) **Assisted movement.**

A. Manual assistance.
B. Special method of suspension (p. 50)
C. Spring assistance.
D. Pulley assistance.

(4) **Resisted movement.**

A. Manual resistance.
B. Special method of suspension (p. 50).
C. Spring (variable resistance).
D. Pulley and weight (fixed-value resistance).

The use of the apparatus must also be considered with reference to the operator. By lifting and supporting the weight of the patient, the apparatus relieves one of practically the whole of the heavy physical effort hitherto required, and the hands are liberated for more delicate and important functions. This enables fine gradations of treatment to be carried out, and undoubtedly allows of a greater turnover in the daily work.

RE-EDUCATION: SPECIAL PRACTICE

Technique of Suspension Methods

When suspension is required for static treatments such as relaxation, it has been found that it is best to suspend the whole body so that it is supported at multiple points; the arms supinated and supported at their centre of gravity. The ropes are then more or less vertically placed in their slots above each suspension belt, as shown in Fig. 6, Chapter III.

When suspension is required to encourage movement (passive or active) it will be found that there are other ways of suspending a limb which will favour and not hinder movement; these are illustrated overleaf. The illustrations show—

(1) Axial suspension (2) Pendular suspension	These are determined by correct starting positions explained in the text.
(3) Spring suspensions	These are discussed elsewhere as they introduce new types of exercise for which no special starting positions are necessary.

For the moment the reader is invited to think only of the simplest type of suspension from a single fixation (overhead beam), and to visualize a limb comfortably attached by slings and ropes to this point. However, the mere suspension of a limb at any casual point is not satisfactory; even though gravity is thereby compensated. A definite *starting position* is necessary, and will be determined with regard to anatomical and mechanical considerations.

The author wishes to stress the importance of a standard starting position, and feels that in earlier publications on suspension methods this point was not made clear, or sufficiently emphasized as to its real importance. If a starting point is agreed upon, any deviations therefrom will be purposeful and will tend to be used for special practice, such as re-education of movement in paralysis.

(1) **Axial suspension**.—In axial suspension the limb will rest in *balance* or *equilibrium*, this is obtained by taking the ropes to

ONE point of fixation which must be over the true axis of movement, the joint. The limb on movement then passes through the arc of a circle in a horizontal plane ; no work is performed against gravity ; all effort made in starting or maintaining movement is

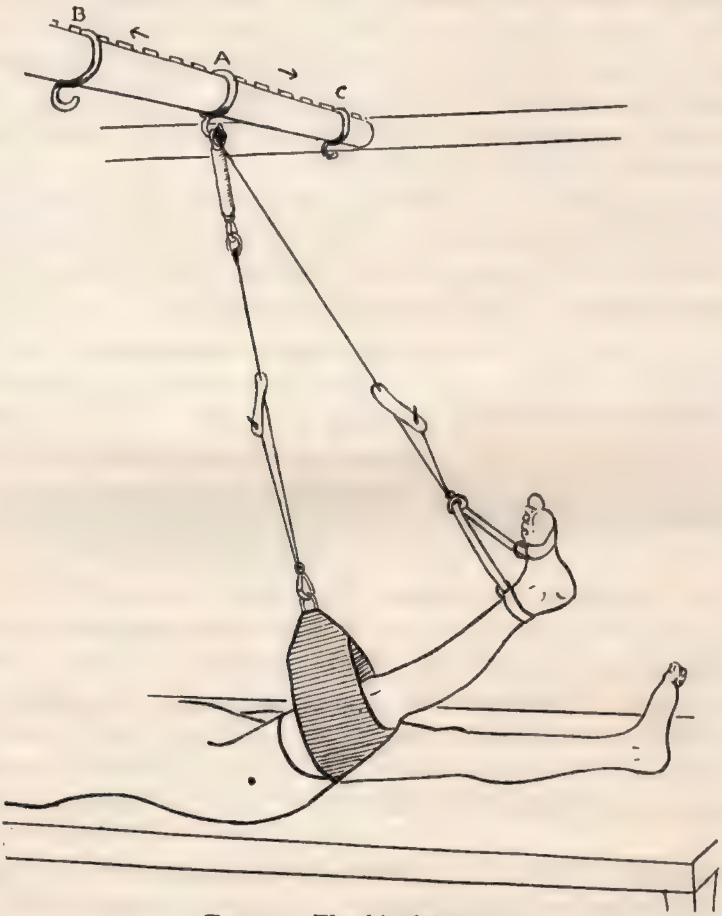


FIG. 12.—The hip joint.

A, Axial fixation for balanced suspension.
B and C, Eccentric fixation for pendular movement.

true muscle work, but of a minimal character. This " balanced " position is the best starting position for testing voluntary movement, and for obtaining the fullest ranges of movement of joints and for most general treatments.

(2) **Pendular suspension.**—In order to set up a pendular movement the usual starting position of balanced suspension in equilibrium must be altered. By altering the fixation point away from the true axis (the joint) an artificial axis will be created, and the plane of movement resulting from this will no longer be strictly

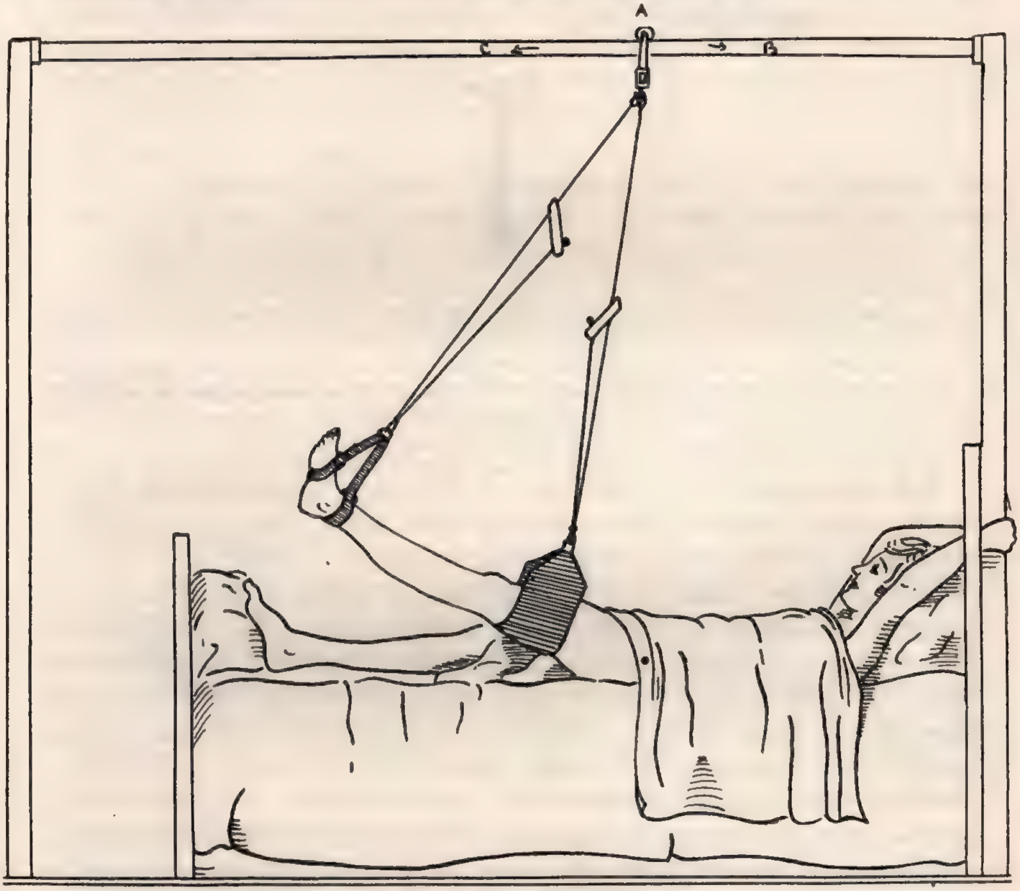


FIG. 13.—The hip joint.

A, Axial fixation.
B and C, Eccentric fixations for altering ranges of movement.

horizontal. The limb will be seen to rise and fall slightly, and a pendular movement will have been set up. The limb will not be in equilibrium, as the axis is no longer vertical, nor the plane of movement horizontal.

There are four directions in which the fixation point can be altered:

(1) Nearer to the mid-line of the body.
(2) Further from the mid-line.
(3) Lateral to either side of a mid-line (as illustrated by arrows in each case.)

FIG. 14.

We can visualize the orbit of this slight pendular movement as a segment of a circular plate. If we put a glass ball in the runway around a solitaire board, and place the latter on a horizontal surface, the ball is found to rest at any point in the track; but if we *tilt* the board, even a little, there will at once appear a particular point to which the ball will return if displaced, although, as in the case of the limb, it will make one or two vibrations back and forth before coming to rest.

Advantages.—The chief use of this type of suspension is the facility with which it is possible to pick out a *particular* group of muscles for work, while eliminating opponent muscles.

The fixation point can be adjusted in such a way that it is possible to assist, or resist, the acting muscles; the limb always returns to the initial position, however small the displacement may be, and it is *this factor* which is taken advantage of to eliminate opponent muscle action. This mechanical principle provides a ready-made means of adjusting movements to suit special cases, and one which can be graduated so that minimal active movements can be increased to those requiring a definite expenditure of energy.

One-way movement and one-way innervation.—In order that a patient may make repeated movements of a particular muscle-group he must be taught to understand the nature of the effort required of him, and the principles underlying this particular method. This involves intelligence and concentration and will not be suitable when treating small children. They must be handled and supervised all the time with detailed work.

The physiotherapist indicates the initial movement in the

direction of the action which the patient is to perform, and encourages him to make a *single* conscious controlled effort in one direction only, and to the words of command, which may be: "Swing up and up," or "out and out" in the effort to get one-way movement and consequently a one-way innervation. If the patient succeeds in timing his muscle effort with the rhythm of the swing effort and rest will alternate, the limb will return by virtue of the slight pendulum movement set up from the altered attachment of the ropes, and no action is necessary by the opponent muscle or by the physiotherapist.

The physiological effect of such movement is "to increase the tension in the working muscles while the tone of the antagonist muscles is decreased," * thus by reciprocal-action, relaxation (or inhibition) of the opponent is achieved. This type of treatment is used for re-education of movement for weak and paralysed muscles.

Special practice in regard to re-education of movement in paralysis

(1) *Balanced and* (2) *Pendular-Suspension contrasted in the treatment of*

Flaccid paralysis.

(1) *Balanced suspension* gives us the means of exciting minimal muscle activity with the aid of rhythmic movement, and so eliminates the risk of fatigue.

(2) *Pendular suspension.*—The one-way movement and consequent one-way innervation permits isolation of a *particular* muscle-group for selective training while the antagonists are relaxed by the steady support of the apparatus and the swing-back of the limb.

Spastic paralysis.

(1) *Balanced suspension* allows of rhythmic, passive movement with full range joint work; also of active rhythmic movement, either symmetrically or asymmetrically carried out for co-ordination exercises.

(2) *Pendular suspension.*—A *very special* advantage will be derived by the use of a one-way movement, as emphasis can be

* P. Bauwens in a lecture to the Chartered Society on Graduated Faradic Contractions.

laid on obtaining *active extension* movements only; the limb returning to the starting position by virtue of the swing-back of the limb. In this way the spastic flexors can be relieved of any active work. (Full details will be found under " Paralysis Treatments.")

Rhythm of effort and rest.—Rhythm is one of the basic necessities in movement, and is so vital that it should be utilized whenever possible in dealing with subnormal conditions. In all suspension exercises, with or without springs, movements are rhythmical in character; effort and rest alternate, and the frequency for a given range of movement is constant. When these conditions are fulfilled exercises can be maintained for quite long periods without appreciable fatigue.

In the functioning of the human body, we see the principle of effort and rest carried out marvellously in certain essential muscles such as the heart, where more than half its cycle is a rest period. It has been calculated that the heart only works nine out of the twenty-four hours, with fifteen hours' rest (Cannon's Physiology). This gives three-eighths work and five-eighths rest. That vital muscle, the diaphragm, also has longer relaxed expiratory periods, with a pause, than its working inspiratory periods.

Muscle-timing.—It so happens that with the rhythm of pendulum swing we can attempt to copy this principle of longer rest periods between short contraction periods, by training muscles to contract only at their most advantageous moment. The remainder of the movement will be carried out by the recoil of the pendulum swing. Careful muscle training will achieve this important principle of effort and rest, so as to approach as nearly as possible the physiological examples quoted above.

The power and leverage of a muscle is greatest in the middle range of its movement, when the tendon is acting at right angles to the moving bone. For example, the best possible moment to obtain a maximum effort from biceps will be the instant the forearm is approaching the midline between flexion and extension of the elbow (Fig. 15).

This is the moment when concentration on " timed action " will gain full advantage of the rhythmic swing of the limb; the pendulum movement will complete the full range under the

impetus of the contraction, and the limb will be carried back in the reverse direction and again swing forward ready for the next timed impulse.

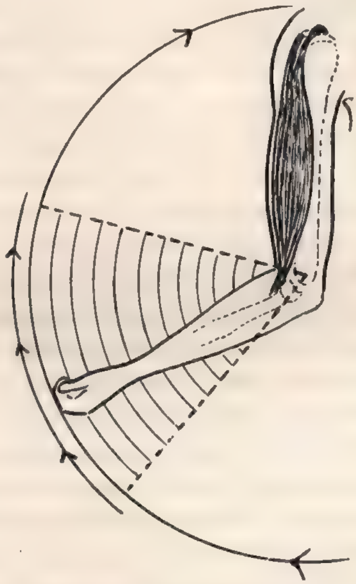


FIG. 15.—Muscle timing.

Technique.—The method is : *First,* to set up and initiate a pendular movement ; once the method is understood it can be carried out by the operator in one single action. *Secondly,* to teach the patient to contract a selected muscle-group at the best possible moment for that particular group. This will result in a " one-way movement " of great value for cases which need exact and careful work.

MECHANICAL AND THERAPEUTIC PRINCIPLES OF WEIGHTLESS EXERCISES

Contributed by A. Dickson Wright, M.S., F.R.C.S., of St. Mary's Hospital, London.

The chief advantage to be gained by this method of weightless treatment lies in the fact that work is graded ; the limb is relieved of its weight before any movement is attempted, so that the

movements of the joints are of a " flail " character and minimal muscular effort produces maximum movement because of the uniform relaxation of the muscles of the limb.

If the limb has not been deprived of its weight, then, before any active movement is attempted, *all the adjoining joints must be stabilized by powerful muscular contractions* in order that effective lever movements may take place with fulcrums at these joints. Owing to the large mechanical disadvantage at which all muscles work the actual pull at the muscle insertions is very great and causes severe pain when the insertions are anywhere in the neighbourhood of the fracture ; fear of this pain causes the patient to inhibit all movements, and no progress is made.

Secondly, every voluntary movement produced by a group of muscles is accompanied by *increase of plastic tone in the opponent group* which ensures smooth, deliberate action instead of snatching. Now if the active group of muscles is weak, or partially atrophied, a strong nervous stimulus produces only a feeble contraction, which does not equal the increased plastic tone of the opponents, and so no movement is produced. This plastic tone is reflex in character and is set up in response to stimuli from tendons and joints ; if all tension is taken off the joint surfaces and tendons by adequate support these stimuli cease, the muscles become relaxed, and the limb can be set swinging with *pendulum* movements kept up by the patient with the very weakest of muscular contractions. The benefits derived from such movements are tremendous, improving circulation, dispersing œdema, stretching and preventing adhesions which are usually extra-articular and produced by the matting together of tissues from inflammatory reaction following the bruising.

To take a specific example :

Dislocation of the shoulder, with injury to the circumflex nerve and the nerve to the infraspinatus.—(1) When any active or passive movement is attempted the first muscles to contract are the small muscles attached to the tuberosities of the humerus, which contract in order to hold the head of the bone against the glenoid to make a firm fulcrum. (Chiefly supraspinatus, infraspinatus, and teres minor.) Now these contractions cause severe pain because the muscles act in the injured area.

(2) The prime action of the deltoid is upwards, only a small component of the force being expended in abduction, as shown in the diagram. (Fig. 16.)

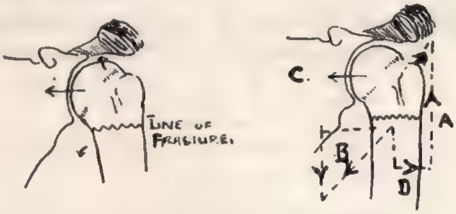


FIG. 16.—" A turning moment."

To overcome this vertical component and to prevent the humerus moving upwards as a whole, the latissimus dorsi and other muscles have to come into action and offer the proper degree of opposition. This contraction of the opponents is entirely unconscious, and thus cannot be inhibited by the patient ; but it prevents any movements as a result of the feeble deltoid contractures. Two forces like A and B in the diagram are known in mechanics as a *turning moment* ; but if the force A is very weak no movement will take place at the fulcrum C. The actual abduction force D is relatively very small, because it is represented by the short side of the parallelogram of forces : let us say it is $\frac{1}{10}$ of the force in the tendon. Now the distance from the shoulder joint to the insertion of the tendon of deltoid is about $\frac{1}{5}$ of the distance from the shoulder to the centre of gravity of the arm, so that the mechanical disadvantage is 1–5, therefore only $\frac{1}{50}$ of the actual pull of the tendon is utilized effectively to overcome the weight of the arm. It can thus be seen how ineffective a weak deltoid must be in abducting a heavy œdematous arm.

Now, to take the weight away from the arm, the patient lies upon his back, thus the weight of the arm is no longer opposed to the deltoid action.

To take the weight off the shoulder joint, the arm, when necessary, braced by a metal splint, is suspended in a sling and hung by ropes from an overhead beam.

When the arm is set swinging on the long ropes there is *no longer any need for* either joint fixation and/or tonic contraction of the deltoid opponents ; the muscle and joint sense reflex system

has been effectively tricked, and no longer does its best to produce the worst possible result (which is the general rule if fractures, dislocations, and palsies are left to nature). As the swinging proceeds the rhythm is taken up by the muscles and the deltoid action is " timed " to take place at the most advantageous moment,

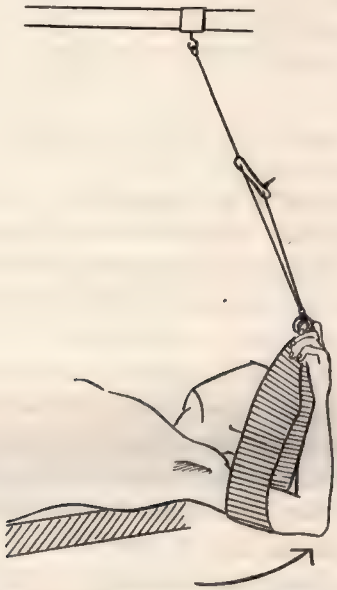


FIG. 17.—Timed action of deltoid.

with the result that its feeble contractions are satisfied by a movement with shortening of the muscle, instead of being dissipated by a straining against impossible forces, with a further stretching of its already tenuous fibres. Thus the vicious circle is ended, and instead of checkmate we have progress.

Chapter V

SUSPENSION THERAPY IN THE TREATMENT OF FLACCID PARALYSIS

A paralysed patient has, unfortunately, many difficulties to overcome on the way to recovery of movement. The actual paralysed muscle is not by any means the only obstacle in the path.

The difficulties are: (1) mechanical; (2) psychological; (3) pathological.

1. **Mechanical.**—Under this heading may be grouped the chief hindrances to movement:

(1) The continuous pull of gravity on weakened structures.
(2) The dead inertia of a paralysed limb.
(3) The added weight of remedial devices, such as calipers or plaster jackets.
(4) The incessant friction of clothing, bedding, etc.

By means of a suspension apparatus, it is possible to suspend a limb or body at selected points, and in this way to balance out the *effect of gravity*; or, in other words, to transfer the weight and dead inertia of the paralysed part to the apparatus. The weight of a single limb is a very considerable item, from 1 to 2 stone in the leg, and 7 to 15 lbs. in the arm. Moreover, a caliper and a remedial jacket weigh many pounds; all these additional weights are also counterbalanced against the force of gravity during treatment.

By suspension, *friction* from contact of bedclothes is eliminated. The only remaining friction will be from the point of suspension itself, which will be nil, *if* this point is placed vertically over the axis of the moving limb; it will then balance the limb in a perpendicular position.

2. **Psychological.**—The helpless patient is in need of encouragement; an ocular demonstration of any (voluntary) movement of the paralysed limb or muscle is the best and quickest way to inspire confidence and induce more effort.

Skilled treatment lies in careful re-education by grading exercise to suit the patient's strength, by variety to prevent boredom, and above all to prevent mechanical repetition. Meticulous care is required with early cases, and with small children who are incapable of concentration—they are not suitable for "self-activity" —they must be constantly supervised by the operator.

3. **Pathological** changes give further conditions hostile to treatment, the chief being :

(*a*) Flail joints and lax ligaments.
(*b*) Circulatory and trophic changes to which are due the " cold blue limbs " of paralysis ; and the atrophy of all tissues in the affected areas.
(*c*) Derangement of muscle balance in posture, and in co-ordination of the whole body due to damage of part of the body.
(*d*) Flaccid paralysis of the muscles themselves.

(*a*) During treatment the flail joints and weakened ligaments are automatically stabilized and protected by being placed in comfortable sling supports suspended from an overhead bar. They are therefore safe from injury.

(*b*) Circulatory and trophic changes. All movements of joints, even though they be passive exercises, promote circulatory changes. The joint surfaces are moved on each other and the great blood vessels over the joints are directly affected. Meanwhile the patient is supported on what might be termed a movable splint. Electrical treatments, with their powerful thermal effects, can be applied while the patient lies with the affected part supported in a corrected position. *For atrophy of flaccid muscles* certain types of vibratory massage can be applied, and are useful in preventing or arresting atrophy. " Movement is life " : therefore, stagnant tissues should be artificially vibrated to secure a better circulation.

(*c*) Derangement of muscle-balance. It is also necessary to think out how to *co-ordinate* large groups of muscles in preparation for walking or standing, and to keep a patient fit while still lying in bed. As patients suffering from paralysis are often kept in bed for very long periods, this is a very important point. It is now possible, with a full-sized suspension apparatus fixed over a bed,

to give all manner of complex movements of a co-ordinated character, such as "walking" and "swimming," even to a bed-ridden invalid.

(*d*) The effort to restore or to develop a new path round the disordered centre in the cord after an acute attack of infantile paralysis must be obtained by muscle training, *i.e.* re-education.

Repeated efforts by the patient are essential in order to re-establish the nerve impulses. These efforts must be built up from a minimum, and continued over a long period of time. They should be varied and made as purposeful as possible. No muscle should, in the early stages of treatment, be required to do more than its minimal dose of exercise, but the innervation must be accurate, and the muscle impulses can be trained and timed to exert their efforts at the best possible moment. It is necessary before starting to re-educate movement to find out what the minimal dose of exercise should be. This matter can be cleared up by a simple method of testing voluntary movement, the paralysed part being suspended in axial suspension.

Tests of voluntary movement.—Suspension can thus be used in the first place *to test* whether effective contractile energy remains, and to demonstrate its presence to the patient; and in the second place to build up muscular power from practically nothing to the condition where more general exercise can be given. The method offers at least two other very important features on the physical plane. These are in connection with the re-education of the muscle-sense and with the early development of muscular power.

The importance of suspension lies in the fact that by its means one chosen muscle-group may be isolated, all other muscles being totally relaxed.

(1) **"Oscillatory" test.**—*Passive movement.*—It has been found that a normal relaxed limb supported in axial suspension, after it is set in motion by the operator, will come to rest after 8 to 12 oscillations in the horizontal plane, *i.e.* to-and-fro movements.

This test is only suitable for the very earliest stages of treatment. To test the power in a limb the patient is asked to assist the movements. If he can do so, the to-and-fro oscillations will be increased in *number*. They may be doubled or continued. Thus the power to move is demonstrated and *proved*, but it is impossible

to say which is the effective muscle-group. The distance test will make this clear, and allow a comparison to be made between the groups.

(2) **" Distance " test.**—The limb is placed in the starting position and steadied. A cardboard ruled as a protractor in the arc of a circle, and marked in inches, is placed under the suspended limb. A small plumb-line should be attached from the extremity of the limb over the zero line of the arc. The patient is asked to make *one* single movement only from the mid-line, and the *distance the limb travels in inches* is noted. The limb is passively returned to the mid-line and the opposite movement is tried out in the same way. The two distance measurements are then compared. One may be 12 in. and the other only 6 in. This comparison *will show the relative strengths* of the two muscle-groups which have been tested (see diagrams, Figs. 18 and 19).

(3) **" Halt " test.**—The limb is next swung (either passively or actively) ; the operator calls " halt " to test first one and then the other group of muscles. The ability to stop a swinging limb at a given signal indicates a good deal of real recovery, and tests the " braking " action of a muscle. It is interesting to watch for the latent period which can be observed in a paralysed limb during this test. Our vocal message takes time to act through the damaged spinal tracts and a definite pause occurs before the halt takes place. *It will be observed during the course of time and as the patient progresses, that this latent period decreases as recovery takes place in the paralysed limb.*

Weight and pulley tests and treatment for the recumbent patient are shown in various diagrams in " Regional Exercises " and in the chapter on " Pulley Therapy " in which further tests of voluntary movement are discussed in detail.

To investigate the amount of voluntary movement in the trunk muscles

(1) *With the patient in total suspension.*—A general survey can be taken as to the extent of bilateral movement, any asymmetry being instantly discernible in the limb movements, and a general view of the function of the trunk muscles is obtainable.

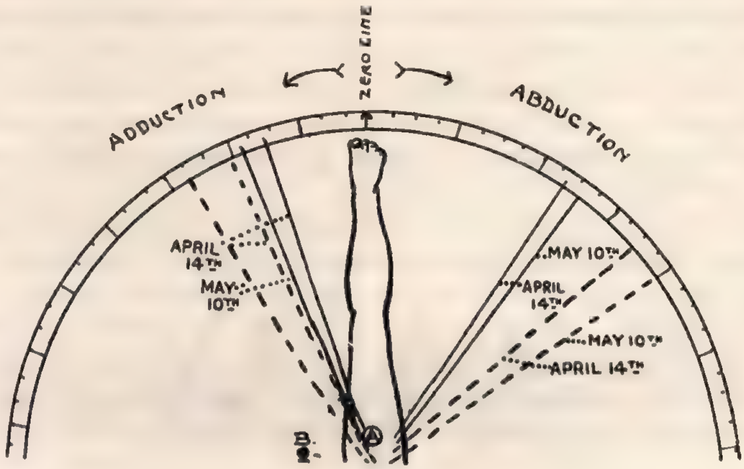


FIG. 18

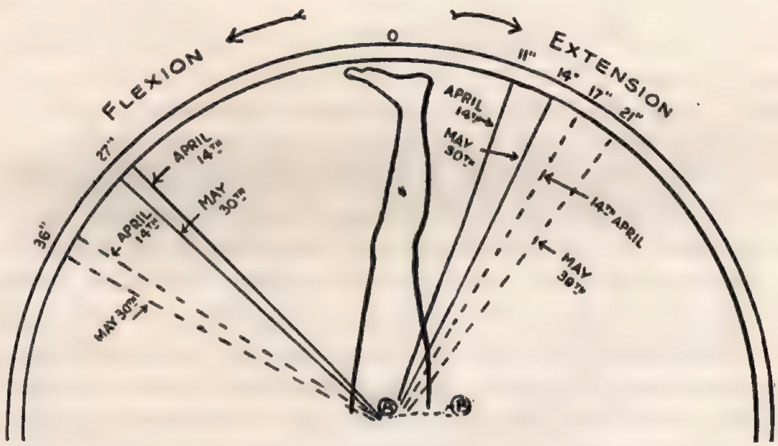


FIG. 19.—Diagram of right hip and leg. Abductors and adductors under test.

Diagrams show the result of a test of voluntary movement taken over a period of little more than a month. They show: (1) which of two muscle groups are the stronger; (2) the slight but consistent improvement made in the limited period under review.

Points (A) in each diagram mark the testing position of "axial fixation." (B) The correct treatment point, when it is necessary to assist one group of muscles, or resist another.

(2) *With the patient in partial suspension* (Fig. 20) a more discriminate and accurate view of the power of the trunk muscles is obtained. By lowering one-half of the body, either both legs, or the trunk, so that one-half is "anchored" and the other half free to move, a fixed point is secured. Assuming the head and thorax to be "anchored," a fixed point will be made, and the pelvis and legs are then slung up; now the lower abdominal muscles can be tested, as the legs move from side to side (Fig. 20). When the legs and lower back are "anchored" (by

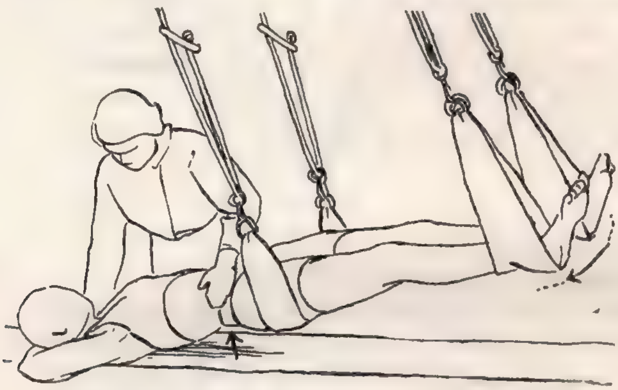


FIG. 20.—Testing for voluntary movement.

lowering them on to the couch) voluntary movements of the head, arms and thorax can be examined.

(*a*) The head can then be moved, so that it is carried in all directions, and any asymmetry of muscle work noted.

(*b*) The neck extensor muscles can be quickly gauged by a head backward extension movement against the resistance of the hand, or of tension springs placed in the circuit (Fig. 83).

(*c*) The strength of the contractions of the lateral muscles of the trunk can be felt, by asking the patient to carry out small, active movements to the right and left sides. Passing the hands under the slings, the motive power of muscles, such as the intercostals and lateral abdominals, can be instantly felt and estimated (see Fig. 20).

(*d*) The strength of the back muscles can be ascertained in the following ways: *side-lying*, back arching, with the legs and

pelvis " anchored " ; this will call into action the upper half of the back muscles. With the trunk anchored and the legs raised the gluteal and lumbar muscles can be examined in their detailed actions.

TREATMENT OF THE LOWER LIMB

Hip abductors and adductors.—The patient must lie on his back with the whole leg supported at two points, foot and knee, from a point of fixation immediately over the hip joint. In this position treatment can be carried out. (Fig. 12. Position A.)

In all tests or treatments it is as well to spend some little time in getting the whole body relaxed, and the patient used to the new position. This will conserve energy for the detailed muscle-work which will follow.

The operator must palpate to find out if the selected movement is masked by " cheating " ; the side flexor muscles of the trunk may work instead of the abductors of the hip joint ; or the adductors of the hip joint may work and then relax as the limb swings back. These are very important matters to guard against, as the movement will be quite useless except for circulatory effects. If " cheating " takes place usually too much effort is being made by the patient, and the isolation of muscle-work has not been understood. The only way to check this tendency is to repeat and analyse the movements most carefully until the fault is ascertained and eradicated. If, on test, unequal muscle-balance is discovered the " one-way movement " technique should be adopted. For example, if one group of muscles is found to be much stronger than the other, and both sets of muscles require treatment, a swinging to and fro will be useless, as the stronger muscles will overpower the weak ones ; it will therefore be necessary to treat each group separately.

If we suppose the abductors to be the group selected for treatment the pivotal point is then altered from axial fixation, so that the angle of the ropes will give some resistance to abduction ; the point of fixation is therefore laterally displaced towards the other leg. (Fig. 12. Position C.) Only a single conscious muscle contraction is now necessary, and is made in one direction, *i.e.* abduc-

tion. The limb will swing back of its own accord in a pendular manner. This " cuts out " all necessity to use the antagonists.

If these adjustments are made with care the patient may be left to practise " one-way innervation " without fear of aimless swinging movements—a most important advantage.

Flexors and extensors of hip joint.—The patient lies on his side with the affected leg uppermost (Fig. 163) and supported at two points, at the foot and the thigh; both are suspended from a point immediately above the axis of the movement—the hip joint. The balanced position of the leg is thus arrived at, and the treatment is carried out in all the details as already explained above. Should the knee joint be flail, it will be necessary to put a short back splint in the popliteal space for its support, and so isolate the working muscles, ileo-psoas, and gluteus maximus.

Re-education of movement while wearing a caliper splint.—It has been found that patients who practise exercises in the suspension apparatus while wearing a caliper, progress much more quickly in the movements of walking than those who do not. Many movements useful for walking exercise can be thought out.

For example:

(1) Back lying, hip up-drawing and down-pushing, with or without resistance.

(2) With an overhead spring resistance, a " pushing down " thrusting movement will use the hip extensors.

(3) Side-lying position, free swinging in flexion and extension of the leg will greatly assist the confidence of the patient in obtaining a full range of movement.

(4) Partial weight-bearing exercises should be practised; the use of a sloping board is most useful, and is described in the chapter on fractures.

A piece of paper placed under the paralysed foot is of service; whether the patient is pressing down or not on the foot can be quickly detected by unexpectedly withdrawing the paper.

(5) Before fitting a caliper, a piece of wooden board should be placed against the feet whenever possible, so that the sensory organs of the feet will get used to contact, and proper stimuli will be induced. Although there is no

sensory lesion, it appears that in some patients long invalidism has dulled the actual awareness that normal people have of substances underfoot. A few exercises practised on grass, gravel, paper, and different floor surfaces can easily be introduced, and will clear up this point, which will otherwise delay intelligent co-operation in movement.

The quadriceps and purposeful movements.—The patient is placed on his side, lying with the paralysed leg uppermost and supported at two points : by the foot and just below the knee joint. The axis of suspension is now the knee joint. The thigh should

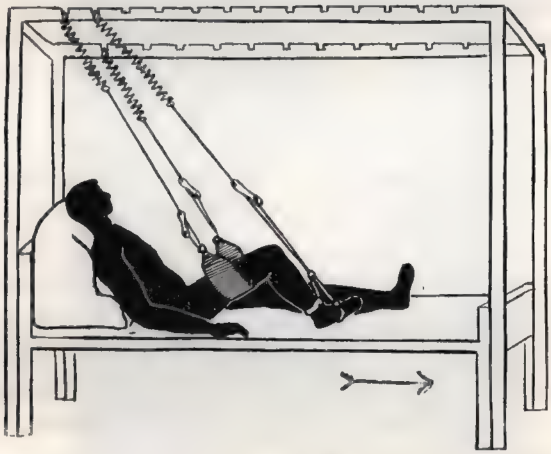


FIG. 21.—Springs used for supporting a flail knee and also for resistance to the active muscles.

be supported on a hard cushion, *and held firmly by the operator*, so that there is no hip movement. With one hand the operator should palpate the tendon of quadriceps, while the other swings the lower leg forward to assist the patient. As the rhythm of the swing asserts itself, the patient should attempt to kick outwards, timing the action, until full knee extension is reached. (Fig. 140.)

An alternative method of supporting a flail knee is shown in Fig. 21, using a sling to support the knee which is attached by the pliable springs to the Balkan beam. The patient thus supported,

thrusts out the whole leg, using the extensors of hip and knee joints against the resistance of the third spring shown in the diagram. This spring is selected so that it is of a suitable strength to suit the power put out by the patient.

Many exercises, with a little imagination, can be made purposeful and interesting. For example, a boy will readily react at the sight of a ball to be kicked, and he will exert every effort, even with a feeble knee, if the opportunity is given to him.

Psoas.—To test and treat this muscle the patient is placed in side-lying, with the upper part of the body fixed, and the affected leg in two supporting slings, both taken from a fixed point over the hip joint. Hip flexions are carried out ; if the muscle is active the tendon can easily be palpated.

Gluteus maximus.—Patient's position is in side-lying, with the upper part of the body anchored, the lower limb suspended by two slings, taken from a fixed point over the hip joint. Leg backward stretching, " holding," and finally manual resisted work, or resistance exercises with graded weights are given.

Fatigue.—The physiotherapist must make a habit of palpating the tendon of insertion of each and all muscles about to be used, so as to detect quickly any change in the quality of the impulses. Fatigue, which is always indicated by a slackening of the patient's efforts, will then at once be noticed ; it is the great danger to guard against when treating paralysis, particularly in the early stages of the disease. The only way to avoid over-fatigue is to give long rest periods during muscle re-education.

TREATMENT OF THE UPPER LIMB

Deltoid (Figs. 22, 106, 107, 109, 110).—The re-education of deltoid is complicated by the activity of the forearm muscles ; these, unless hindered, may work as abductors and even flexors of the shoulder joint. Therefore, to obtain isolation of the deltoid it *may be* necessary to splint the forearm at right angles to the upper arm, with a light metal splint (internal or external-angular), or more simply to put the forearm out of action by making the patient hold on to the supporting ropes, as shown in the illustration.

Position of patient.—The patient lies on his back, the arm and forearm at right angles are suspended at the level of the trunk and "balanced" in such a way that the patient can relax and get used to this feeling and position. The physiotherapist first sits at the side of the patient and swings the arm gently to and fro, giving only passive movements in very small ranges, in order to educate

FIG. 22.—Re-education of the deltoid.

A case of circumflex injury resulting in very severe paresis of the deltoid in a man of 60 years. For this case a right-angle splint had to be applied to localize muscle action to the deltoid. Every muscle except the correct one seemed to "take charge" until this device was thought out. (Case under the care of Dickson Wright, M.S., F.R.C.S., St. Mary's Hospital, W.2.)

the sense of direction. As the rhythm of the swing is understood by the patient, active movements should be asked for and timed to take place at the most advantageous moment. For the deltoid muscle it will be half-way between the body and the shoulder level. The tiny contraction efforts of the muscle will now work with the minimum of fatigue and strain. By altering the pivot point

supporting the limb " one-way movement " can be set up, if assisted or resisted work is required (see page 50).

To test the patient's *innervation* a " halt " is called at unexpected intervals, so as to check up on the muscle recovery. It is not easy for a paralysed muscle to stop the momentum of the swinging arm ; if this can be done it indicates a considerable amount of recovery and power to " put on a brake."

A double-sided exercise suspending both arms in the same plane is liked by some patients ; it gives a " feeling of balance," and assists innervation with the aid of associated movement. (Fig, 104.)

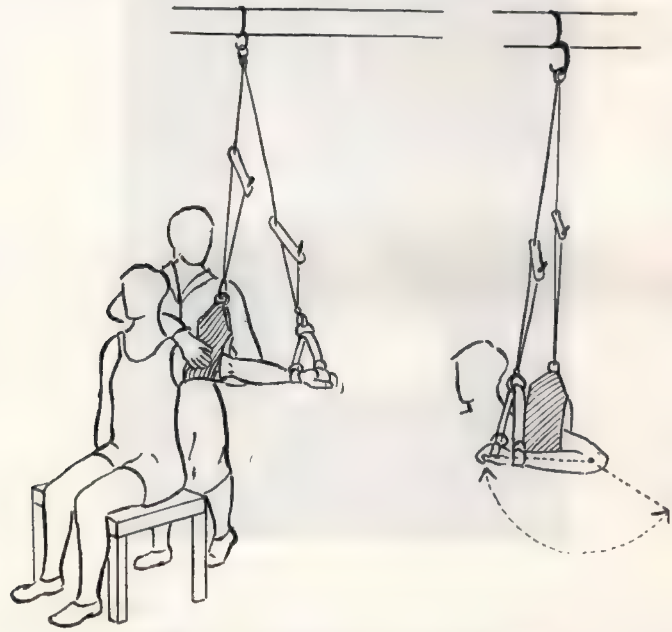


FIG. 23.—Biceps and elbow movement.

Trick movement.—The operator will, of course, control the range of movement during this treatment, and should constantly examine the muscles to see that there is no humping of the shoulder due to trapezius action, nor adduction of the arm with the back swing. There is real danger of this occurring if the patient is insufficiently instructed, left alone, or carelessly placed in a bad starting position.

Biceps (Fig. 23).—The patient sits under an overhead bar, the arm and forearm supported by ropes and slings. Both ropes must be hung from the same point, which must be situated over the region of the elbow joint. The physiotherapist holds and supports the upper arm. The best moment to bring the biceps into voluntary action will be as the forearm approaches the right-angle position. The operator should palpate the tendon of biceps during the active work to assess the power of the contraction.

TREATMENT OF THE TRUNK

Co-ordination exercises involving groups of muscles have not hitherto been easy to carry out in the treatment of Flaccid Paralysis, but it is now possible if a full suspension apparatus is available. The whole body can be suspended at selected points. The inclusion of a set of short graded coil springs will allow buoyant movement to be carried out in both horizontal and vertical planes, or long spiral springs are used if resistance is required.

Plaster bed.—A patient can be lifted from a plaster bed by slings and ropes, so that he is totally suspended ; the body is thus raised 4 to 6 in. off the bed, and lies clear of all encumbrances and pillows. Both legs should be raised by the four slings which are placed at ankles and thighs, then the head is raised in a similar manner. With a narrow belt passed under the waist, the patient is first lifted up 2 in., so that the broader belts can be slipped under the heavier shoulders and the pelvis, then the raising movement can be completed. The inclusion of two pulleys in the rope circuits of the heavier regions assists the physiotherapist in the manœuvre ; the heaviest patient can thus be raised with ease, and single-handed in case of need ; the patient's movements can be controlled with the lightest touch.

The patient can also move as freely as his strength permits in "natural" movements, arching against the spring resistances. The buoyancy of the graded springs makes an exhilarating exercise very similar to that which is felt when floating on water. (Fig. 25.)

Back exercises performed regularly will strengthen atonic muscles which have become weakened through prolonged lying in

FIG. 24.—Swimming exercise.

bed. As a result of strengthening the back muscles energy will be released for fixative and synergic actions which must occur when the semi-paralysed limbs are moved.

Swimming-pools are installed only in certain specialized hospitals, but with the use of this buoyant-suspension method, the joy of free movement is within the reach of all bed-ridden patients.

The relatively trivial cost of the initial installation, the portability of the apparatus, which can be made to wheel over the patient's bed, is one of the advantages of using suspension apparatus.

"Swimming."—Fig. 24 shows a model in full swimming action. Swimming is one of the finest means of keeping fit and of exercising the whole body, but a proper co-ordination of movements has to be learnt.

Respiration is increased by these activities, and the patient will have far more confidence when attempting to walk if these exercises are thoroughly practised as a preliminary measure.

Alternatively the patient can lie supine, holding on to the apparatus, and moving the limbs from this position.

To teach the co-ordination of leg muscles, the patient holds on to the upright of the apparatus, as he would to the bar of a big swimming bath. The leg movements are then taught, for they are the most important ones in real swimming. Breathing and relaxation between the movements should also be learnt. The "circular kick" and the "crawl" movements can be carried out: for the "crawl" the legs move slowly up and down from the hips, the legs being held straight with toes turned in; the depth of the kick is a matter of practice.

The "breast stroke" with the arms is now added, and the "dog paddle" with the hands can be practised.

Leg and arm movements should next be co-ordinated, so that there are the same number of strokes to each leg cycle; breathing is synchronized to each arm cycle.

Pool therapy is another ideal method of treatment for the paralysed. The buoyant effect of the hot sulphur springs of the Continent, or the fine home waters of Bath and Droitwich, remove the weight of the paralysed limb, and the patient, enjoying the bath, kicks and plunges about, thus getting movement of the greatest physiological importance. The impulse for movement starts in the brain and travels down to all the limbs, in an outflow of energy, resulting in movement of some sort which is most encouraging to the patient, and helps to restore the lost function

of the limbs. The exact control and isolation of muscle action is not so easy to obtain by this means as it is on a suspension frame. A fulcrum or support, is *absolutely essential* in order to isolate movements that call for special re-education. Movements in water are apt to be misleading because of the assistance to the abductor muscles of both limbs and of resistance to the adductor muscles when they compress the water during movement ; moreover there is no way of measuring this resistance. The ideal arrangement is to use both methods of treatment for the paralysed.

A list of general remedial exercises which can be given in suspension apparatus is enumerated ; in favourable cases a marked improvement in health and spirits usually follows such free work.

GENERAL EXERCISE WITH SPRING-SUSPENSION

Position of patient.		
I	Total suspension, supine, and then in prone lying.	1. General correction of posture. 2. Side bending. 3. Hip updrawing, down thrusting.
II	Body anchored, hips and legs suspended on slings.	1. Pelvic tilting, pelvic rotation and lifting. 2. Hip rotation. 3. Alternate hip updrawing. 4. ,, ,, flexion and extension, with pulley and rope support.
III	Side lying.	1. Hip flexion and extension of both legs. 2. One leg cycling movement (upper leg).
IV	Pelvis anchored, head and thorax slung on springs.	1. Side bending, holding, alternate sides. 2. Backward arching against resistance. 3. Trunk rotation.
V	Head slung.	Head backward pressing and relaxing, and other movements against resistance.
VI	Breathing.	Breathing exercise interspersed throughout the treatment to improve general condition and counteract scoliosis.

The chronic patient.—In this chapter it is chiefly the early stages of re-education of movement for paralysed patients, which

have been dealt with ; much further careful muscle-training will be required, including weight-bearing exercises before the patient can get about, and be considered fit for discharge from hospital. Much can be done for polio patients *after* their discharge from hospital. This period can be filled to some extent, by teaching carefully selected self-activated exercises to the patient : these he must learn to carry out for himself under *occasional* supervision. It is a matter of common observation that when a patient becomes

FIG. 25.—Natural movement.

In suspension apparatus, the two arms being fixed points, the body can be exercised in very free movements.

fit enough to carry on a normal life the stronger muscles are apt to " take charge " while the weaker simply do not function ; they lapse out of the realm of consciousness, and become inert. This will lead to progressive unbalance of function. Many such cases then return to the hospitals for treatment or advice.

If in such cases of unbalanced function the *weaker group only* is isolated and put through daily exercise, muscle sense is reawakened, the muscles will usually respond, and sometimes respond above all expectation. By reinforcing the weak muscles, and training these

to do their part, a better balance of muscle power becomes available and the whole physique improves. The improvement is, of course, only relative. It is well known that full recovery is impossible, but the condition of the patient's life can be made more tolerable, and he may be able to carry on his life or occupation with more ease if this type of modified treatment can be made use of.

Out of many cases, only one is chosen to illustrate this point. A woman, aged 35, an old polio case of some eight years' standing, was sent to consult the medical officer of the electro-therapy department of St. Mary's Hospital, W.2. Her occupation was that of a music-teacher, and the instrument the cello. She complained of much difficulty in walking and had increasing pain in the legs and back ; the rest of her body was normal.

After testing her voluntary movement by the *tests* already described, it was found that the adductors had become very strong from continually gripping the cello. The abductors and glutei were correspondingly weak, and were in fact hardly ever put into use in her sedentary, but busy, life.

Selected suspension exercises were given to the glutei and abductor groups only (the atonic muscles). A wide range of movement was carried out so that the antagonists were thereby relaxed and stretched by actual movement *and reciprocal-action.* Almost at once the weak muscles began to function, muscle consciousness in these groups was restored, and a better balance of muscle strength resulted which was felt throughout the whole limb.

The patient was intelligent and very grateful for the help which had been given to her. She understood the wisdom of carrying on this method of treatment at home, and proceeded to fix up various gadgets so as to help herself.

The same problem of unbalanced muscle action reveals itself and is very liable to occur from unvaried occupation. Everyone knows how flexion deformity of the spine is often seen in the gardener, the labourer, or in sedentary workers such as the dressmaker or shoemaker. The flexors are always in use, full extension movements are rarely used.

It would appear that all patients who are under vocational

training should have a daily period of *stretching exercises.* A short dose of extension movements is absolutely necessary to counteract this tendency to flexion deformity or contracture, which is the lot of the manual worker and those who carry out sedentary occupations, and is also such a marked feature among the aged. The simple pulley-and-rope exercises detailed in a following chapter will fully meet the need.

It is to be hoped that with the new ideas on vocational training, aided by occupational therapy, all sufferers will in time be able to look forward to a happy and useful future in spite of their disabilities.

It should be a matter of national concern to all of us, to see that these patients are rehabilitated, so that they can once again become wage-earners, and normal citizens.

Some cases of anterior poliomyelitis treated with the sling-suspension-apparatus and other forms of physiotherapy at the Hospital for Sick Children, Great Ormond St., London.

Contributed by Dorothy Lewis, S.R.N., M.C.S.P., Sister in Charge of Physiotherapeutic Department.

So much has been written about this disease and its treatment that it seems superfluous and somewhat presumptuous for me to add any further contribution to the subject. Yet one still comes in contact with cases where deformities have occurred owing to lack of proper support in the early stages. A case that comes to my memory as of recent occurrence is one in which definite deformity had developed.

The particulars are as follows :

GEOFFREY EDWARDS, AGE 2 YEARS.—This patient first attended this hospital on Oct. 6, 1941, the onset of the disease being eight weeks previous to this date, he had been treated as a case of pneumonia and discharged.

The condition was one of marked left foot-drop, some wasting of the anterior tibial group, contraction of tendo achilles, and tibialis posticus, with invertion of foot, and general weakness of the whole leg. An electrical test was made and showed reaction of degeneration of the anterior tibial group and of the peronei muscles.

Fig. 26.—A calcaneous splint designed by Mr. Dennis Browne, F.R.C.S.

Treatment consisted of correction of the deformity by application of Mr. Browne's calcaneous splint, which supports the foot in exaggerated dorsiflexion and coercion. This splint is of recent design and is the only one known to me which will keep the foot in full dorsi-flexion; it is used for correcting equinus deformities of any kind (Fig. 26).

Daily treatment was given of infra-red irradiation and of exercises in a deep bath of warm water, and re-education of affected muscles in the zero position, eliminating gravity on a *smooth, polished board* and massage (Fig. 27).

Fig. 27.—Re-education of shoulder movement.

Sir Colin MacKenzie's method of re-education of movement by the use of a polished board, so that friction is eliminated and the force of gravity controlled.

Either the zero position is used for treatment or by tilting the board, assistance, or resistance, can be applied to the working muscles.

On alternate days an interrupted sinusoidal current was applied by means of leg baths.

Later a faradic bath was used instead of the sinusoidal current, and as periodic electrical tests were made and showed some response to faradism, that current was employed by the labile method.

Exercises in the sling-suspension apparatus were given, and consisted of hip flexion and extension, leg abduction and ad-

duction, knee flexion and extension, swimming and back extension.

The condition March 18, 1942.—The deformity was corrected, and the child able to fully dorsiflex, and to evert the foot against gravity, had the full use of his toes, and was able to walk and run normally. The child is still attending for treatment and observation as the girth of the affected leg is still less than that of the other side, but there is every hope of complete recovery. The general condition of this patient was much strengthened by the full range of trunk movements available by the use of the suspension apparatus.

Other cases of interest are:

Aiden Ravenscroft, age 5 years 2 months.—Under care of R. S. Frew, F.R.C.P., and Eric Lloyd, F.R.C.S. Anterior poliomyelitis: onset Dec. 10, 1934.

Condition.—Paralysis of left side of face, and of the intercostal muscles. Weakness of both legs, the right being worse than the left. Some weakness of the abdominal muscles, of erector spinæ in the dorsal region and of the rhomboids.

Treatment.—The child was supported in a frame of light construction, with the legs abducted and inwardly rotated, and the knees very slightly flexed, the feet dorsiflexed, hips extended, and the back supported. He was placed in the Drinker apparatus for artificial respiration. He was taken out of the frame every four hours and pressure points attended to. Physiotherapeutic treatment consisted of infra-red irradiation twice daily, and gentle passive movements of all the joints. After the first three days very gentle massage was added, and the patient encouraged to try to perform active movements.

As recovery occurred, warm saline baths were given, and later a galvanic bath, breathing exercises, and vibrations to affected side of face and to the intercostal muscles.

When all tenderness was gone, labile faradism was given to the intercostals and abdominal muscles, erector spinæ rhomboids and the affected muscles of legs and face, also general massage. A progression was made as the patient recovered by exercises in the suspension apparatus, for legs and back.

On March 16, 1936, the child was having a scheme of double-sided exercises for back and legs, and breathing exercises. The face had recovered.

This patient was discharged with complete recovery of function of all muscles. He came to see us last summer (1941) and is perfectly well and strong.

BRIAN CRUST, AGE 3 YEARS 10 MONTHS.—Under the care of Donald Paterson, M.D., F.R.C.P. Admitted Sept. 16, 1936. Diagnosis, anterior poliomyelitis ; onset fourteen days before.

Condition.—Flexors of hip weak R<L.
Gluteii ,, ,, R<L.
Upper limbs weak.
Abdominal muscles weak.
Intrinsic muscles of feet weak.
Diaphragm N.A.D.

Extract from doctor's letter.

Treatment.—Support in frame. Infra-red irradiation and exercises in saline baths twice daily. Removal of frame and passive movements of joints every four hours. Gentle massage.

Feb. 17, 1937.—Interrupted sinusoidal bath instead of infra-red. Exercises in suspension-apparatus. Murray-Levic bath for intrinsics of feet.

May 28, 1937.—Electrical test showed normal response of all muscles to the faradic current. Discharged with complete recovery of all muscles.

MOIRA COTTON, AGE 2 YEARS 3 MONTHS.—Under care of Dr. Paterson (Physician), Mr. Browne (Surgeon). Diagnosis, anterior poliomyelitis ; onset Sept. 4, 1941. First attended Great Ormond St. Hospital Aug. 21, 1941.

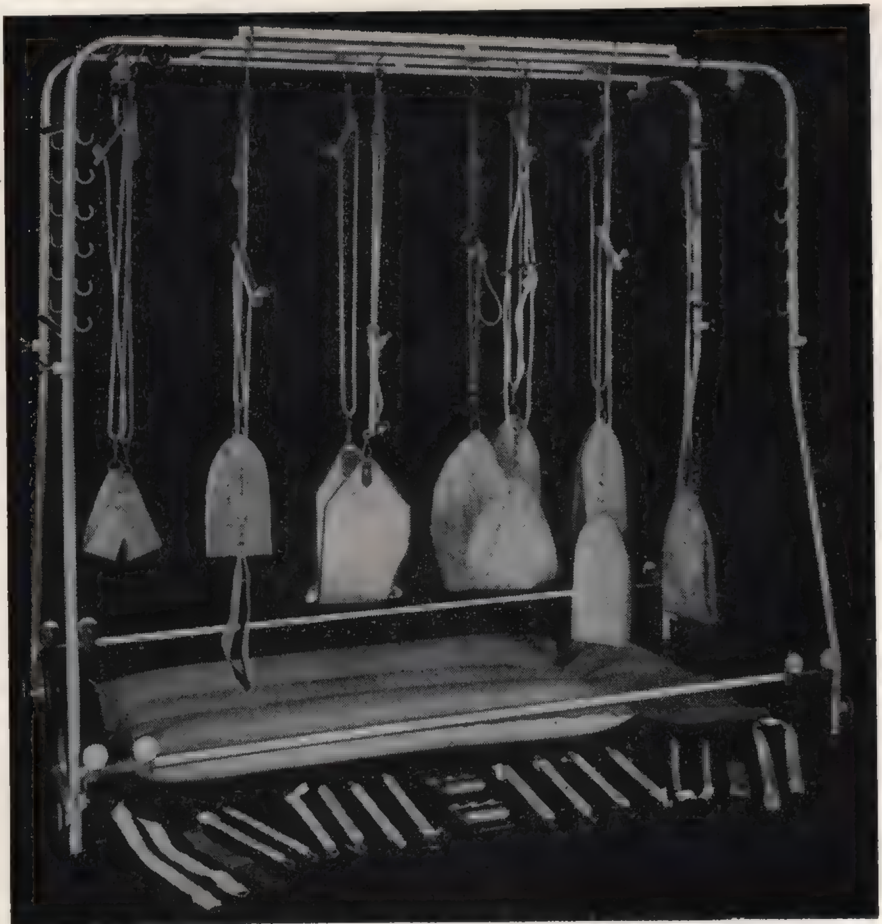
Condition.—Definite wasting of right quadriceps extensor.

Treatment.—Infra-red irradiation and general massage to leg. Exercises in the suspension apparatus. Interrupted faradism to quadriceps extensor, commencing with the leg in extension, progressing to a slight degree of flexion, increasing at each treatment the degree of flexion, the time and the current, until finally the leg was moved from a right-angle bend at the knee to complete

extension at every contraction of the quadriceps, moving the electrodes, so that the rectus femoris, then the vastus internus, and lastly, the vastus externus were treated to avoid tiring the muscle, and yet to obtain contraction against resistance of gravity. In this way the child was able to take the current for twenty minutes at a time and be quite happy looking at a picture-book.

Jan. 27, 1942.—The child was discharged cured. Both legs measured 10½ in. round the thigh, and were of equal girth and strength.

These are the general lines of treatment as practised at this hospital for anterior poliomyelitis.



Stanley Cox & Co.

Fig. 27A.—"Universal" sling suspension apparatus.

Chapter VI

SUSPENSION THERAPY FOR RELAXATION AND IN THE TREATMENT OF SPASTIC PARALYSIS

RELAXATION

"Tone of mind and body both act and re-act on each other"

Normal healthy life is made up of periods of effort and rest. The strain of modern civilization is now so great that rest in itself is greatly curtailed, and a habit of mind is created which forgets how to rest and relax. In addition to this, there are many abnormal conditions of the body which prevent rest and relaxation, and it is for such conditions that relaxation by physical methods is particularly suited.

Sufferers from these abnormal states include, above all, the spastic and paralysed patient, the neurasthenic, those suffering from the after-effects of trauma, and cases when hyper-muscular and hyper-vascular tension is present. It has been the author's experience that the doctors she has worked for, have been only too interested and not a little surprised to hear that the physical exercise department understands and appreciates relaxation; and that the department is able to put forward various definite schemes by which relaxation is put into practice. These schemes will be described in this chapter.

The prime cause of tension is fear: the fear of being hurt; the fear that the injury is not sufficiently recovered to be ready for treatment; fear of pain and the habit of muscle guard; and many other fears often not of such apparent origin. Many people are totally unaware that they are tense. They have lost the power of relaxation and repose, and have to be taught to realize this. Even in bed such persons are so unrelaxed that they show irregular breathing, wrinkled forehead, tense eye-muscles, and mental and emotional activity, which wakens them from half-sleep by a reflex start.

In abnormal conditions where muscle tone or tension is above

the normal, one's aim is to educate the individual to behave normally; in other words, to lessen permanently the tension which has become a bad habit. This might be illustrated by the familiar instance of motor-car control. A driver must be prepared both to accelerate and to slow-down his engine at the right moment if he wishes to be a proficient and careful driver. If we can use this simile in regard to the body, thinking of action as acceleration and relaxation as deceleration, it will be agreed that the learning of both is important and essential, if we wish to have proper control over our bodies.

Learning relaxation is a difficult matter; indeed, it is a life study. The methods suggested here are based on the late Mrs. Archer's system as practised at King's Langley, and handed on to the physiotherapists by Miss Mortimer, M.C.S.P. The additional use of sling-suspension apparatus has been found greatly to assist the process of learning, and to bring relaxation within the realm of practical treatments that can be carried out in ordinary hospital practice, and within the scope of short treatments.

Hospital patients are usually a simple-minded and trustful class. They are much more amenable to suggestion and treatment, and do not offer the mental opposition so often found in other types of patients. As a rule they have but little knowledge of the meaning of the term relaxation. Not even that superficial knowledge possessed by people whose wider experience and general knowledge is greater than theirs. Therefore different methods of relaxation will suit different cases; some react to total relaxation, for others local relaxation will suffice. The question is how best to relax a patient? Several methods will be explained in detail.

Total relaxation means the relaxation of the whole body. The process first starts by *quietening the central nervous system by mental relaxation.* Then the busy optic tract is rested by closing the eyes. This is followed by deep breathing, especially expiration, as this decreases tension in the spine and chest, then soothing massage can be given as if for insomnia.

At the outset it must be understood that relaxation means a relative or partial slackening of the tissues. The patient must be told to realize that rest and relaxation should radiate from his central nervous system towards the tips of his fingers and toes;

that is, from " the centre " to the periphery. In these periods of deep repose we are as near the mastery of our mind as we may ever obtain. We achieve a state to obtain practical control of mind and body, and to concentrate on that power of self-help and self-adjustment which is behind all healing processes.

Technique of relaxation in suspension.—The whole body is under treatment. The patient is instructed to lie flat on his back and to " let go " his weight, so that every part of his body is borne by the sling supports on which he is lying. Fig. 6 represents how this is best arranged for relaxation purposes.

The head is supported in a special sling cap made for comfort, the neck muscles must be relaxed, the eyes kept shut, the jaw loosened, and the facial muscles should become as expressionless as possible.

Both arms must be placed in partial abduction and supported on slings, which should hold the limb at its centre of gravity just above the elbow joints, with the forearms supinated, and extended.

The legs are slightly abducted, extended, and supported at the thighs just above the knee joints and at the ankles.

The thoracic and pelvic parts are raised, so that the whole body rests on the sling supports, and the patient lets go his whole weight in complete relaxation.

The operation of lifting and adjustment of the patient in slings is simple and practical. A floating sensation is felt; this is coupled with a complete confidence in the stability of the apparatus, which must be strong enough to support the heaviest patient. A sense of quietude steals over the patient and some degree of relaxation should be obtained even in a short time. The patient should preferably be screened off from others at this time and talked to in a soothing voice, or, better still, left quite alone to acquire the habit of lying still and achieving true repose. Some people are very difficult to influence and the inexperienced operator is apt to try to do too much, endeavouring to obtain relaxation and attempt mobilization of the joints or other complicated treatments all at the same time. This is not good practice and leads to disaster, especially with spastic cases.

The great advantage of relaxation in suspension is that it is easy to learn and yet rapid in effect. This method has the

advantage in that the *floor* (*or support*) *is brought to the body instead of the body slowly giving up its weight to the support.* When one lies down on a flat surface the prominent points of the body, such as heels, head, hips, shoulders, are in contact with the surface and it takes a long time for the rest of the body to let go in relaxation.

FIG. 28.—Standard and Balkan beam outfits in use at Park Prewett Emergency Medical Service Hospital.

In the large apparatus a relaxation treatment is going on ; in the smaller apparatus a patient is shown exercising his quadriceps against the resistance of an overhead spring.

The patient should have absolute confidence in his support, and the more comfortable the support the better. Care in the manner of handling patients and getting their trust and response cannot be too meticulous.

Warmth is an important factor in relaxation, and if an electrically heated blanket is obtainable it can be placed under the patient inside the sling supports while he is suspended. Relaxa-

tion should, if possible, be carried out in pleasant, warm surroundings, with heating lamps directed on the patient and (for luxury people) in a room decorated in pale shades of soothing colours.

Breathing.—The operator should direct his own and the patient's thought to quiet repose until a plastic state of mind is acquired. To assist this process deep expirations must be made; audible sighing expirations, if possible, as this will also assist the letting go process of the spine and chest wall. If the expirations are deep and searching, the following inspirations will also be deep and health-giving, causing better ventilation of the blood. At the same time, as tension lessens in the chest, the spine will relax and be gently lowered to rest its length on the supports. Breathing steadily relaxes tension of joints and muscles, and then the brain itself, so that the patient may even drop off to *sleep*. With regard to sleep, it is interesting to note that "Changes of tension of muscle are called changes of tone, and are due to nerve impulses; tone is greatest in excitement, *least during sleep*, reduced by anæsthetics, and lost when the nerve is severed." * Therefore, it will be correct practice to induce sleep for all very tense and spastic subjects, especially during the early days of treatment so as to obtain fundamental rest before progressions are attempted.

To test for relaxation.—From time to time it is necessary to test a patient, and find out how much relaxation he has achieved. Fortunately this is very easily and accurately done in the suspended state. A swing is started in any one limb, the rest of the body being lowered to the couch for stability; then the number of oscillations to and fro that the suspended limb makes are counted, before it comes to rest. In normal states the relaxed limb usually makes eight to ten oscillations. If the patient is rigid or spastic this swing is pulled up short, or there may be no oscillation at all. As treatment progresses, these tests give a clear indication as to whether improvement is taking place or not.

Massage.—Gentle stroking massage will in some cases assist the process of relaxation. Soothing strokings can be applied along the course of the peripheral nerves, starting as near the spinal centre as possible, and working to distal parts. The larger the area that comes under treatment the greater will be the effect.

* *Applied Anatomy and Kinesiology*. Bowen and McKenzie.

The head and the facial muscles are stroked while the patient gradually relaxes the jaw. The neck muscles are gently kneaded with soothing rhythmic movements of the finger-tips, especially in the region of the prominent tendon of the sterno-cleido-mastoid muscle.

The limbs are stroked from above downwards, the movement is carried over and beyond the finger-tips.

The thorax and abdomen are stroked with long, large movements ; the hands follow the body contours as closely as possible.

Local relaxation as a preliminary to rehabilitation.—Relaxation should be a preliminary step to nearly all treatments, especially in the case of *traumatic injuries*, when there is much pain as the result of the injury. Only local relaxation of the limb may be required for these cases, and a method of relaxation is indicated which is called the " Contrast Method." By this means the patient is taught to tense a group of muscles, and hold the position for a while, then suddenly to let go. From the experience of the sensations thus gained, and after some practice, he will realize the difference in the two sensations of tension and relaxation, and will then learn to appreciate the term " letting go." To illustrate this point it is often difficult to educate the grip of patients who have sustained a painful hand and wrist injury. All sorts of associated muscle actions come into play : such as flexion of the trunk, screwing up of the facial muscles, turning the head, and other actions ; in fact anything, rather than flexion of the fingers, accompanied by a synergic extension of the wrist. With such a patient it is as well to explain the anatomical position of the muscles involved, to demonstrate that they are quite short, lying along the forearm only, and that but a small effort is required to put them into action. If the two arms are crossed, and a hand-shake grip is established with the operator, a trial of the " contrast method " can be demonstrated, then repeated by the patient. (Each hand should make alternately a quick, gentle grip, and then relax.)

As it is most difficult to inhibit a quick bilateral movement we can, by " tricking " the innervation, cure bad habits of associating the wrong muscles, and more quickly produce accurate muscle control.

The Contrast method of relaxation is also given as a general treatment. All muscle groups are alternately contracted and relaxed in turn while the patient reclines on a comfortable couch. The operator tests the degree of relaxation by lifting the limb and seeing if it is limp. To progress the treatment the starting position is changed to sitting or even standing, so that the relaxation process can be localized to a single limb. Usually stretching exercises follow, an arm of one side and a leg of the opposite side being stretched and relaxed in alternate rhythms. Deep breathing is practised throughout the treatment.

Progressive relaxation.—Edmund Jacobson of Chicago recommends a form of relaxation which he calls " progressive," and for these reasons : The patient is first taught to feel the difference between the feeling of contraction and letting go, which has here been called the contrast method. The larger muscle groups are tried out first.

The second step is to contract the muscle without moving the part, then to let the muscle go limp by degrees while under constant mental control.

Thirdly, the patient has to try to achieve relaxation without a previous contraction so that an apparently relaxed muscle becomes even more completely relaxed by this progressive method. The patient should lie flat to practise these exercises, beginning the contractions with the larger muscles until all have been brought into use. As a further progression, what Jacobson describes as " differential relaxation " takes place. For this the patient must slowly rise from the lying position, sit on a chair, and then relax in the chair. From this relaxed but new position further " progressive " relaxation is carried out.

The indications for his treatment are chiefly vascular hypertension and conditions of pain, strain, and over-activity. Jacobson's last book was produced in 1938, and is based upon careful physiological investigations into the physiology of rest and relaxation.

SPASTIC PARALYSIS

The types of cases of spastic paralysis most frequently treated in the physiotherapy department at St. Mary's Hospital, W.2, have

been cerebral tumour, encephalitis lethargica, hemiplegia, disseminated sclerosis, under the direction of Dr. Wilfred Harris or Dr. Dennis Brinton and Dr. Justina Wilson.

Since all the conditions are central nervous lesions of the brain or cord many serious symptoms become evident, and go far beyond a mere peripheral deformity. The patient may be ataxic, spastic, and inco-ordinated. Mental relaxation may be lacking and is depicted by tension of face and neck muscles. There may be some deformity and flexor contracture.

Because of these far-reaching symptoms it is usual to divide physiotherapeutic methods into general and local treatments.

General treatment.—The aim is to do everything possible to relieve spasm and to produce relaxation.

Gentle general massage with radiant heat is generally ordered, and great emphasis now lies on the careful application of real *passive* movement—not a joint being forgotten.

Various relaxation methods are available, and with the use of these it is hoped to influence the mental and higher centres. By reciprocal-action through the reflex centre in the spinal cord the muscular condition will also be influenced.

Local treatment is directed to special symptoms which may arise in each individual case and will include :

(1) The prevention and correction of deformity.
(2) The encouragement of movement. Large range of movements rhythmically and bilaterally applied whenever possible.
(3) Co-ordination of movement directed to stimulating *extensor* rather than flexor action by " one-way movement," * then the practice of fine movements of a precise nature will be carried out by Frenkel's exercises.

Treatment by simple or buoyant suspension.—Relaxation carried out in suspension apparatus is fully appreciated by the spastic patient, as it is found to be comforting and refreshing. The physiotherapist will have something special in the way of treatment to offer these patients. Life for them is tedious, and so little can be done, the little we try to do may as well have a sound physiological basis. For the same reason the physiotherapist will also obtain a certain amount of mental satisfaction in the work.

* See p. 51.

Technique.—Special care is necessary when dealing with neurological cases: it should be seen that the limb is in perfect equilibrium. In previous chapters much stress has been laid on the necessity for axial support (over the main joints), but it is also necessary to exclude any tendency on the part of the patient to "hold" the limbs; therefore the limb should be suspended *at its centre of gravity:* the upper limb at the elbow, with the forearm supinated and extended, if possible; the lower limb at the knee, with the foot supported. In addition, this limb should be slightly abducted and extended.

With deformed patients these conditions cannot be fulfilled; for these subjects it will be necessary to find the best point of equilibrium by trial—care being taken to use large, soft slings, so that they will automatically adjust themselves to the contour of the body.

It has been found that a gradual introduction to this method of relaxation is best, as the patient's confidence must be won; thus, one can start by suspending the two arms, then the two legs, and so on, till the whole body is under treatment.

For some neurological cases simple suspension without springs is the best method, as the aim of the treatment now described is to carry out rhythmic movements in a smooth arc of a circle with a relaxed swing. For other cases, and as a progression, spring-suspension can be substituted, with good effect.

Passive movements of the suspended limb are initiated by the physiotherapist. These offer movement of the simplest type, but the range of movement should be made as full as possible. By this means the patient is made aware of his limb movements in space; the cortical function will be stimulated, the idea of movement is kept up, and the joints will not be allowed to stiffen.

Active movement to follow relaxation.—The patient should be asked to perform only the easiest and most rhythmic movements immediately after a relaxation treatment; otherwise spasm is apt to recur, and the time previously spent will have been wasted. A swinging movement is the easiest, and with the patient relaxed in a suspension apparatus, movement is available at once, without rearrangement of either patient or apparatus. In some cases music may be a help—a slow waltz can be put

on a gramophone and the patient asked to move arms or legs within a small range of horizontal movement in time with the music. Double-sided rhythmic movements should be continued until both relaxation and rhythm in movement have been gained, and the range increased. This can be progressed until all four limbs are working, and the sense of " floating " has been well established in co-ordinated movement.

Co-ordination.—Asymmetrical movements are the natural progression to symmetrical. A " halt " called during the movement of a limb will involve a sudden braking action to stop the momentum of the swinging limb ; if this can be carried out without an increase of spasm a high degree of improvement will have been achieved. The two limbs can, and should, be put through asymmetrical movements—one travelling upwards towards the head, while the other moves downwards towards the feet. Later, all four limbs can be moved smoothly and correctly in quite a complicated series of movements.

Concentration on *extension movements only* can be arranged by altering the axial suspension point so that a " one-way movement " * is obtained and the flexion action eliminated. It is only necessary to move the fixation points several notches in a lateral direction ; the limb will then tend to return or swing back of its own accord till it hangs in a vertical position under the fixation point. All the work in moving it *from* this point will be carried out by one group of muscles, *i.e.* the extensors ; and a pendular movement, instead of a flat arc of movement, will take place ; thus the extensor group will be stimulated while the flexor group will be inhibited.

In this way much real controlled work can be given ; very little fatigue is experienced, thanks to the rhythm of movement and the pendulum swing.

The joint and muscle reflexes are gently stimulated, and, above all, the cortical appreciation of the limb moving in space is revived.

All these exercises make a good preliminary to bilateral exercises with Pulley and Pole, and Frenkel's exercises.

Frenkel's exercises follow on well after the rhythmic muscle-training described above. These exercises must be performed so

* See pp. 49–53.

that the patient can watch his own movements, which should be of a very precise nature. All encouragement should be given to promote a keen interest and attention to detail on the part of the patient.

As the muscle-work in Frenkel's exercises is complicated, involving lifting the limb itself in some cases—sliding it in others—and following very exact instructions necessitating balance and static work, it will not be possible to do so much in each treatment as was previously the case with suspension exercises, as these exercises are a progression in treatment. Great care must be taken not to overtire these patients.

A few of these exercises are appended at the end of this chapter.

A case of very severe spastic paralysis (*hemiplegia*).—The case of J. M. is selected for description, as this was a very severe case of hemiplegia. The particular interest in this case is that he was one of the first of our hospital patients to be treated by relaxation and traction methods *only*. (St. Mary's Hospital, London, Professors Pannett and Langmead.)

Diagnosis.—" Tumour of pre-rolandic area of the cortex, condition inoperable, the skull trephined, pulsating tumour visible."

His condition presented the following disabilities and characteristics : Severe contractures with clonic and tonic spasms of the left arm and leg. The attacks of spasm were so severe that the knee contracted on to his chest and had to be forcibly removed. The tension of the neck muscles was such that the sterno-cleido-mastoids were permanently prominent and rigid. The facial expression was strained and anxious ; the speech slurred, his manner was highly irritable, and he was completely helpless. On the doctor's instructions the aim of treatment was restricted at first to entirely passive methods :

(1) To relieve spasm and quieten the nervous system, as described in the previous chapter, by relaxation.
(2) To correct the severe contractures by gentle manipulations and massage.
(3) To devise a method of maintaining the limbs in this corrected position (see Fig. 29), and while in this position to induce deep repose, even sleep if possible.

The shoulder was always treated first; suspended and by degrees abducted. The elbow joint was then straightened out, the forearm supinated, and finally the wrist was properly aligned. Attempts to stretch out the fingers were made, but were usually quite unsuccessful.

FIG. 29.

The photograph of this patient was taken years ago and shows a first and crude attempt to relax and extend spastic limbs. The chief interest lies in the fact that at that time, ten or more years ago, we were not aware of how to make use of *reciprocal-inhibition*, or at least that it had a very practical application to our work in physiotherapy for the purposes of relaxation. It will be noted :

(1) That the limb was held in extension, which, though a useful technique for this case, was not the best way of obtaining extension.
(2) That all the finer points on the technique of suspension are missing—the limbs are not " properly " supported in the ways now advocated.

The tonic spasm of the arm muscles yielded in the typical " clasp knife " manner ; this was found to be the best moment to fix the arm in extension to the special extension-bar. (Visible in

Fig. 29.) In this way it was possible to retain these corrected positions for a considerable period. The general relaxation treatment was continued until the patient dropped off to sleep. During sleep the limbs were held in extension by the use of the apparatus, and the contractures were overcome for that period. By degrees, relaxation induced a quietening of the nervous system and a reduction of reflex irritability. The mental and emotional states were rested and improved, and there was improvement in the general condition. The facial expression grew less anxious and the patient looked younger, while his sleep and appetite greatly improved.

The result of the treatment in view of the diagnosis and prognosis was remarkable. Although the patient was quite helpless, he gradually became able to walk a little, after much careful treatment, at first with a support, then without, until finally he bought a motor-tricycle which he was able to ride and control !

In appearance the patient was still a very spastic and hemiplegic case ; yet he had gained considerable control and power over his muscles, and once improvement was established there was no relapse.

FRENKEL'S EXERCISES

Leg Exercises.

In lying.—The patient lies on the back with the head raised so that the eyes can follow every movement. The foot remains in contact with the couch throughout the movements.

(1) Flexion of one leg in hip and knee—extension.
(2) Flexion of one leg in hip and knee, abduction of knee, adduction of knee—extension.
(3) As in (1), but physiotherapist calling " halt " during flexion —extension.
(4) Exercises 1, 2, 3, with two legs.

Timing must be slow and even, each movement is performed three or four times in succession.

Progression is made by patient lifting heel off the couch.

(5) Flexion of one leg in hip and knee to place heel above patella of other leg—extension.

(6) As in (5), but heel is placed halfway up opposite tibia—extension.

(7) Lifting of one leg to place heel on opposite great toe—lower.

Progression is further made by making the range of joint movement smaller, and later by alternating the movements.

(8) One limb is flexed ; while being extended the other is flexed and then extended.

In sitting.—The greatest practical importance is attached to such movements as sitting down and getting up.

The patient sits with knees abducted and feet resting with outer borders on the floor. He must be taught adduction and to keep limbs in a normal position.

Sitting down.—The knees should be flexed slightly and the body bent slightly forward. The patient then begins to sit down, flexing his knees still further and continuing to bend the trunk forward. The body is slowly lowered into the chair. Care should be taken that the patient's ankles do not turn over or that he is not pitched forward.

Standing up.—Both feet should be drawn back until the heels are partly under the chair. The body is bent forward until the knees are partially extended, then he slowly erects his trunk.

In standing.—*Walking sideways.*—This is easier than walking forward, and teaches the patient to transfer the body weight from one leg to the other.

Patient makes a half-step (14 in.) to the left, closes up feet, returns to original position. This is performed in six stages as follows :

(1) Body weight resting on right leg.
(2) Body leans to left and left foot brought down to floor.
(3) Body weight even on both legs.
(4) Body rests on left leg and right heel lifted.
(5) Body leans to left and right leg freed.
(6) Feet brought together.

Walking forward.—Lines should be marked on the floor at even distances about 12 in. apart.

Walking slowly, keeping feet on lines, the feet are parallel and

the heels brought together after each step. The base should be 6 in. broad.

Turning round.—The patient should stand with his feet close together. He turns slightly on one heel; he then lifts the other foot off the ground and puts it down by the side of the first, so that the initial position of the feet is resumed.

ARM EXERCISES.

Diagrams for copying.—As an exercise preliminary to the instruction in handwriting various simple diagrams are used, consisting of straight lines, angles, spirals, zig-zag lines, and circles. These patterns are drawn out on stout cardboard and should be used for following the outline with a pencil. They give a means of comparing progress from day to day.

FIG. 29A.—Paraplegia. Showing patient with Complete Transverse Lesion at Thoracic Vert. 2–3 being prepared for "swinging exercises" at Ministry of Pensions Hospital, Stoke Mandeville, Aylesbury. See Appendix 5 for treatments.

Chapter VII

SUSPENSION THERAPY FOR CORRECTION AND MANIPULATION

SPONDYLITIS

In the treatments described in this chapter an entirely different use is made of suspension apparatus. The use of *weight and counterweight of the body* itself is utilized for manipulation and correction purposes for the treatment of special conditions, such as spondylitis deformans and scoliosis.

Fig. 30.—Spondylitis deformans, in a man of 48, under the care of V. H. Ellis, F.R.C.S.

Spondylitis is arthritis of the spine, and as such its treatment is much the same as that of osteo-arthritis in any joint. It occurs chiefly in two main forms: (1) *Spondylitis-deformans*; (2) *spondylitis-ankylosis*.

Spondylitis-deformans is a slowly progressive arthritis occurring about mid-life and more often in males whose occupation has thrown strain on the back muscles. It is associated with a characteristic stoop. The chief symptoms are increasing stiffness and pain, which may or may not be severe, and are caused by pressure of osteophytes on nerve roots or to reactionary fibrositis of muscles and ligaments. Fig. 30 shows such a case of spondylitis deformans in a man aged 48.

Time was, when both these classes of spondylitic patients were regarded as hopeless problems from the point of view of physiotherapy. Now we find that the treatment which is about to be described does much to keep down the degenerative process, to relieve pain, and to restore a certain amount of function, even in fairly advanced cases. Breathing exercises should be taught and

practised daily by these patients. Massage, heat by short-wave therapy, diathermy and various forms of hydrotherapy are of great benefit, but the treatment should be one that is carefully thought out on lines leading up to muscle strengthening by exercise.

Ankylosing spondylitis is a far more serious condition of early adult life. It is nearly always an infective arthritis, often beginning with vague pains and then more definite muscular pain in back and shoulders. These pains are often passed over as "rheumatic," but an X-ray taken at this period will reveal the early and characteristic changes of ankylosing spondylitis, which usually starts in the sacro-iliac region, and invariably creeps into the inter-vertebral and costo-vertebral joints, until the whole spine becomes stiff and rigid, and the thorax completely immobile. Shoulders, neck, ribs, knees and ankles are too often involved, and the picture is one of general deformity, accompanied by muscular wasting and pain. Even in these cases great relief can be given and a considerable amount of function restored by daily exercises to mobilize the joints.

The treatments described in this chapter are largely dependent on the activity of the patient himself, and chronic cases certainly improve if they persevere with treatment. Their treatments must be kept up, otherwise the mechanical forces due to displacement of the line of gravity will be too much for the patient to resist, and the spine will revert to the flexed position and become rigid.

Aims of Treatment

(1) *For early and new cases.*—To promote Relaxation, to soothe pain, and to prevent the extension of the stiffening to other joints, by movement of these joints.

(2) To promote Breathing ; Local : to special areas of the chest ; General : for the sake of the heart and lungs, so that these organs may gain some relief from pressure.

(3) *For chronic cases.*—To maintain Correction, or to gain it : using weight and counterweight of the body itself to attain our object :

(*a*) By stretching the anterior structures, fascial or muscular, which always tend to drag the patient down ;

(*b*) At the same time, by automatically *holding* the stretched position, so that the origins and insertions of the posterior muscles are approximated as far as possible, without muscular effort ;

(*c*) Also, in this stretched position, by getting the patient to contract his atonic muscles against very carefully graded resistances, until such time as his muscles have acquired some tone.

Only by actually gaining extension of the spine will the flexion deformity be overcome by physiotherapy.

Treatment

(1) *Relaxation.*—The treatment is as described in Chapter VI.

To soothe pain.—Electrical treatments are of great value. Deep X-ray and Short-wave therapy have a deeply penetrating effect on joint structures and greatly aids the circulation. Its application to the whole spine, sacro-iliac region and the hip joints is very effective.

To prevent extension of the arthritis to other joints.—It is wise to keep mobile all joints not yet affected. Gentle massage will do great good by improving circulation and nutrition. The patient is encouraged to make active efforts if he feels soothed and refreshed by massage. The chief joints to be inspected, and which need prophylactic treatment, are the following : shoulders, jaw, sterno-clavicular, hip and, above all, the costo-vertebral. All movements must be self-activated, as only the patient himself can tell how much he can tolerate and at what moment he should stop. To make it possible for him to carry out active movement weightless exercises are indicated for the limbs and back, breathing exercises for the chest. Even so, care must be taken to persevere with treatment only during remission periods, and not when acute attacks of pain are present.

(2) *Breathing exercises.*—Gentle but persistent breathing exercises are essential; they should be localized to the costal area against manual resistance. Constant practice will gradually establish better control of the neuro-muscular mechanism of the costo-vertebral region, and some mobility of the stiffened joints may be regained and perhaps retained.

Generalized breathing is given in the suspension apparatus. The arms are supported so that their weight does not hinder chest movement, the back is supported and extended as far as possible, and then deep breathing is carried out to expand fully the whole thoracic cage. Deep respirations are essential in themselves, as the lungs and heart are greatly impeded in their work by the characteristic posture of this unfortunate complaint. Such exercises, by removing pressure from organs and from the bony vertebræ and discs, will allow a better flow of the circulation to these cramped parts; all this will be of considerable value in arresting atrophy and rarefaction.

(3) *Correction: Weight and counterweight.*—To maintain or to obtain correction it is necessary first to stretch the anterior structures—muscular, fascial and ligamentous—which are always contracting and tending to pull the body into acute flexion; next to tone up, or try to tone up, the elongated atonic muscles of the back. These two purposes can be fulfilled at one and the same time. The patient's body, supported under the dorsal region from the overhead bars, acts as the weight, while the head and arms act as a counterweight. This method of slinging will put a slight correction strain on the spine. The patient's intelligent approval must be obtained, so that the purpose of this treatment must first be thoroughly explained and understood. He should try to relax in this partially corrected position.

The sling fulcrum on the dorsum gives the patient a purchase over his own back that otherwise he is quite unable to obtain; therefore he will be able to make voluntary contractions of the back muscles. So, little by little, with no risk and no bruising or force, the patient is encouraged to stretch and contract within the limit of his capacity.

The operator should sit behind the patient, supporting the head lightly, while the patient presses back against the resistance of the supporting coil springs. The actions of the neck muscles can then be estimated by the finger-tips. The importance of head movements is particularly stressed, as it is only by this means that the tight cervical fascia can be stretched (Fig. 31).

The upper dorsal muscles are next investigated by placing the finger-tips inside the belt supporting the back. The patient's chin

FIG. 31.—Treatment of spondylitis deformans by weight and counterweight methods.

Note the dorsal sling acts as the fixed point from which the purchase is obtained, the head and arms are suspended on spring suspensions.

should be " held in " while the back muscles are contracted. Meanwhile the arms should be pressed backwards against their spring supports; in this way a shortening of the transverse and longitudinal back muscles is obtained, while the chest muscles are stretched.

After a while the patient will have registered the proper sensations obtained from putting these groups of muscles into action, and he may be left to carry out the exercises alone, while he is lying in the correction belts. The apparatus is so easily adjusted that the tension strains can be instantly and minutely varied. Constant care is required by the operator to see that all is well and that the patient does not overdo his treatment.

FIG. 32.—A case of old caries, Pott's disease of the spine.

It is impossible for a *much deformed subject* to lie on his back on a bed or couch. Fortunately this drawback can be overcome by partially suspending the patient so that the back is supported by a broad sling, which adapts itself to the abnormal curvature. From a semi-sitting position the patient gradually reclines against the belt. The head must be supported in another sling, and he can then be slowly lowered until he is lying in a comfortable position on the supports. For severe cases of deformity the correction can only be a very gradual process; but even in such cases it has been found that muscle-tone can be increased.

If more pain occurs as the result of treatment too much will have been attempted, and it is as well to stop all exercise for a few days and resort to passive and soothing treatment.

For some years we have treated by this method a large number of cases at St. Mary's Hospital, W.2. They have been mostly cases sent to our department by Mr. V. H. Ellis, the orthopædic surgeon.

Fig. 32 shows a patient with very gross deformity as the result of Pott's disease. He was sent for treatment "to mobilize the hip joints and to straighten the legs as much as possible." Self-activated movements were ordered as they were considered the only safe method of treatment for such a case.

It will be noted that in spite of excessive deformity, this patient was able to lie on his back in perfect comfort.

FIG. 33.—Lying on his back for the first time in his life and in perfect comfort.

As a result of treatment the hip movements were somewhat improved, and the muscles regained some tone by these self-activated exercises. (V. Snell, F.R.C.S., and Dr. Creighton.)

SOME EXERCISES FOR THE TREATMENT OF KYPHOSIS AND WEAK BACK WHICH CAN BE ADDED TO ANY REMEDIAL SCHEME

Simple kyphosis is an exaggeration of the normal curve of the spine in a backward direction, in the dorsal region; it is always accompanied by a weak and toneless condition of back muscles, and a contraction of the pectoral muscles.

The back muscles chiefly affected are the transverse or longitudinal groups ; in some cases both these groups may be at fault. Weak rhomboids cause a sagging outwards of the scapula, so that the bones appear too prominent, either in the whole length of the vertebral border or more often at the inferior angle. Associated with this symptom is a tendency for the humeral heads to be rotated inwards, so that on an anterior inspection of the patient these bones are more prominent than in the normal subject. This condition is due to atony of the infra-spinatus and teres minor muscles. Excessive forward slope of head and neck is the symptom associated with weakness of the longitudinal erector spinæ group ; it may be a compensatory posture, and is a very common feature occurring in quite half the kyphotic cases who come for remedial treatment.

FIG. 34. — Kyphosis and bad posture in a schoolboy aged 16.

Although the latissimus dorsi muscle is not usually mentioned in the musculature of kyphosis, this muscle has a very important function to perform. It acts as a "corset of the spine," and when weak and atonic it allows a further sagging of the trunk. Moreover, in treatment, it is a difficult muscle for the patient to visualize and localize.

(Fig. 35.) **Treatment and correction of the curve by posture.**—If the fore part of the body is suspended in such a way that the weight of the trunk falls between the two fixed points, namely, the pelvis and the arms and head, a partial reversal of the kyphotic curve and an excellent correction can be obtained. As the spine sags forward the anterior parts of the vertebral bodies are opened up and the pressure on the chest is released. The muscles of the trunk will at first be "on guard," and tend to resist the

sagging movement. As the position is continued, the patient is instructed to co-operate in the corrective process by relaxing his muscles. Thus, the first aim of this part of the treatment will be achieved: *Relaxation in correction.*

Fig. 34 shows the patient standing in his natural posture.

The X-ray report stated no rotation or scoliosis. "The lump seen on the left side is soft and appears to be partly muscular."

Fig. 35 shows the preliminary position of relaxation in correction. The patient lies prone on a plinth, both arms being supported in slings placed under arms and forearms, while the forehead rests

FIG. 35.—"Correction." (Note, additional slings should support the upper arms, or the chest; they were removed for purposes of photography.)

on the back of the hands. The ropes are then adjusted from the superstructure, so that the fore-part of the body is lifted in slight hyperextension, and just clear of the couch, but not so high as to cause lordosis. The legs are strapped to the lower bars of the apparatus or to the plinth. This position must be kept up for several minutes, and the time gradually increased, as the patient gets used to the corrective strain.

This relaxation in correction is the keynote of success, and the process cannot be hurried; it is not easy for kyphotic subjects to learn to reverse the positions that they have held for so long. A

strain will be felt on shoulder joints or in the spine, but they must gradually get used to this and learn to co-operate by making further efforts at relaxation.

Not only does this slung position correct the obvious faults in the kyphotic spine, but as it removes pressure from the anterior parts of the vertebræ the actual spinal circulation will be improved and accelerated as the pressure is lessened ; even though this is only a temporary matter it is important. Meanwhile the muscles of the pectoral region are put on a considerable stretch, while the over-stretched back muscles are *automatically held* in such a way that their origins and insertions are approximated ; therefore, they are in the very best position for localized contraction efforts, which are the next objective in this treatment.

The patient's mental concentration is now called for in order to obtain selective muscle work, chiefly of the erector spinæ, the deep intrinsic muscles and the transverse back muscles.

To stimulate and work latissimus dorsi.—In all persons where muscle tone is imperfect, the body tends to spread outwards and away from the mid-line. In order to correct this the patient is instructed to draw himself together—" not to spread so much." This is a difficult exercise, and should be repeated until it is understood, and the " corset " function of the muscle encouraged.

Latissimus dorsi is also the muscle used in extension, adduction and inward rotation of the arm (as in the back stroke of swimming).

With the patient in semi-suspension, slight resistance on the elbows and a command to move the arms downwards and backwards will give a good resisted exercise, and make use of all parts of the muscle. Meanwhile this exercise leaves the head unsupported, therefore the erector spinæ will function strongly, to hold the position of the head against gravity.

To work latissimus dorsi yet another way : the patient can be placed on his back in full suspension with the hands grasping the framework of the apparatus ; in this position he is instructed to pull himself upwards in a climbing action, while the operator grasps the ankles giving strong resistance. An excellent fixed point is obtained if the operator's arms are braced against the uprights of the apparatus. Resistance springs can also be used for self-activated exercise as described in Regional Exercises. (Fig. 87.)

Localized mobility exercises.—When giving a lateral, passive or active mobility exercise in semi-suspension, it is necessary to strap the patient firmly down to the plinth; the physiotherapist places one knee in contact with the patient's thorax and the opposite hand and thumb over the area to be localized in order to control the movement. With the free hand the patient is swung unilaterally and towards the thumb of the fixing hand. The position of the physiotherapist must be reversed to get the same effect for the opposite side. (Fig. 36.)

FIG. 36.—Note how the ropes are arranged. A tilt is given to the body so as to obtain a rotation and side flexion strain.

Active mobility exercises can be carried out by the patient lying prone with the arms placed behind the neck. He can swing himself from side to side while the operator controls the swing with one knee and both hands, thumbs placed uppermost. "Unilateral halts" can be introduced by the physiotherapist. This will induce very strong and strengthening muscle work: it is very difficult to hold the body away from the vertical slung position for more than a few seconds.

N.B.—The couch should be covered with non-slip material, the patient very firmly strapped to the couch, or bottom bar of the apparatus, as the exercise of side-swinging is a vigorous one.

To Sum Up

(1) Correction is achieved by reversing the curve; gravity assists the work as the upper and lower parts of the body are held as fixed points.

(2) Physical strain is thereby lessened for the patient, and more mental energy can be used to concentrate on repeated localized

contractions of the large and small muscles of the spine. Moreover, as there is little fatigue due to assuming and holding the position, the actual effective contraction period can be greatly extended and more often repeated, than can be done in most remedial exercises.

(3) The intrinsic muscles of the spine must be stimulated to contract.

(4) Throughout the treatment the operator has no weight to carry, and can therefore feel with the fingers the quality, and accuracy, of the muscle work.

SCOLIOSIS

The body-weight is used in many ways for the purposes of corrective exercises in remedial gymnastics, especially for the

FIG. 37.—Stretch crook-hanging; the feet can be placed lightly on a gymnasium stool to save undue abdominal strain, while the spine is strongly stretched.

FIG. 38.—Half stretch-grasp, half grasp side-lying over boom.

scoliotic patient. All cases of scoliosis are given from time to time such exercises as grasp-hanging from wall bars, so that the weight of the body will extend the whole spine. (Fig. 37.)

Fig. 38 illustrates side-lying over boom, when a more definite corrective effect is obtained by direct pressure, accompanied by a pronounced stretching of the structures on the concave side. The position is, however, so uncomfortable that it cannot be sustained long enough for the correction to be very effective.

Suspension with a Swedish head sling apparatus is used in every hospital, and it can be worked out in several ways by altering the starting position from standing, sitting, or cross-leg sitting positions. These exercises have a more direct effect upon the *upper* region of the vertebral column, and supply a traction on the spine which is otherwise difficult to obtain.

To correct a " C " curve the Swedish remedial exercise of arch-side-leg-lying-holding is illustrated (Fig. 39). It is one of the most

FIG. 39.—Half neck-rest half rotate out, side arch-leg-lying-holding.

FIG. 40.—Oldewig's strap exercises.

effective exercises, as the correction is by muscle action alone. The patient's trunk projects over the end of the plinth and an excellent correction is obtained, the curve tends to be reversed, and the muscles on the convex side have to hold very strongly to resist gravity. Again, however, fatigue is involved, and to such a degree that the exercise can be repeated only a few times at each session.

Oldewig's strap exercises.—Many physiotherapists will be familiar with Oldewig's " strap exercises " (Fig. 40). These exercises are partly passive and partly active in effect. The operator places a strap (webbing with handles) under the greatest convexity of the spine, then pulls it upwards in order to obtain a passive correction and partial reversal of the curvature. In

addition to a lifting movement the operator puts on a rotational strain, so that one hand will be pulling harder than the other in the upward lifting movement ; in this way an oblique correction is obtained. The patient is then taught to contract his muscles downwards against the strap. These strap exercises are excellent for the treatment of kyphosis and scoliosis in young children ; but they are really only suitable and effective when the relative strength of the operator is greater than that of the patient. The method is tiring and cannot be sustained long enough to produce much definite effect.

Weight and counterweight correction in suspension.—Certain selected scoliotic patients can also be treated in suspension apparatus. The method is similar to, but is an improvement on the strap exercises, as it allows long, sustained traction and fine adjustments. Patients are taught to localize movements to the *small* muscle groups.

(Fig. 41.) The patient is suspended in a lateral supine position, pivoted over a fixed point (belt) placed under the maximum point of the curvature. The upper and lower ends of the body are then lowered so that a corrective strain is produced over the flexure due to the curvature. In favourable cases the curve is reversed, the spring suspension supporting head and limbs automatically adjusts the weight, yet allows some movement. A torsional strain is then arranged, so that at the same time the trunk is rotated and stretched in order to correct the scoliotic deformity. This is done by adjustments in the *lengths* of the supporting ropes in the dorsal area, which enables them to exert an *unequal* oblique tensile force, as indicated by the small arrow. The pressure and counter-pressure thus produced can be kept up for considerable periods of time. The patient then contracts his muscles over the only *fixed point* and is able to reinforce this action by small, vertical movements of the head and legs ; these movements are permitted by the spring suspension at either side of the fixed point.

The idea of small contractions often repeated is to work the small intrinsic muscles of the spine (Fig. 42) rather than the long muscles. These small deep muscles of the convex side are automatically held in their inner range by the mechanical aid of the apparatus. The patient has only to concentrate on *one thing*, and

that is to make repeated small contractions to produce side-flexion. The movements are assisted by the slight vertical movements of the head and legs and are made possible by the spring suspension points.

When, after a period of treatment, the patient feels fatigued, it is *not* necessary to take him out of the apparatus; all that is required is to alter the exercise: to give a different type of muscle work—for instance, a backward arching with an alteration of the arm position. This new exercise is called a "distracting" exercise, and will remove all fatigue due to the former work. The side flexions are then resumed to obtain further correction

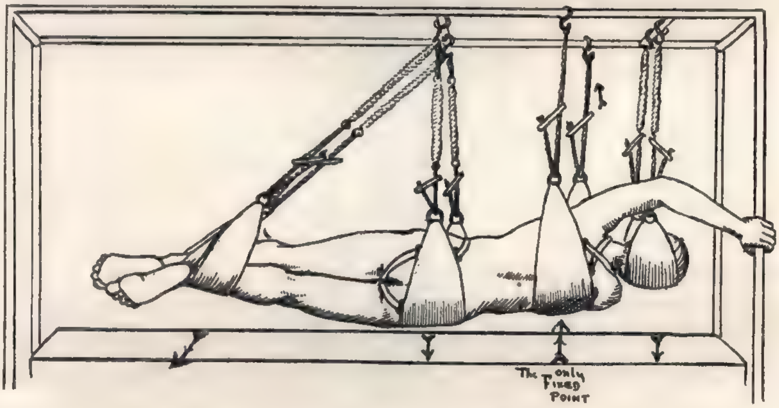


FIG. 41.—Correction in suspension.

and more distracting exercises are thought out; flexion and deep expiration will serve to illustrate the point. In this way the therapeutic effects of correction can be carried out for quite fifteen to twenty minutes, and are only limited by the degree of *sensory* pressure on the skin over the scoliotic area. This sensory effect is then made use of: the patient is asked to stand; walk; or carry out a balance exercise; to attempt to hold himself in the same corrected way as when in suspension; as the sensory effect remains many minutes it is a valuable means of directing the will power of the patient to the particular area under treatment.

The author is indebted to Mr. T. Stamm, of Guy's Hospital, for the term "distracting exercise" and for a valuable lecture he gave

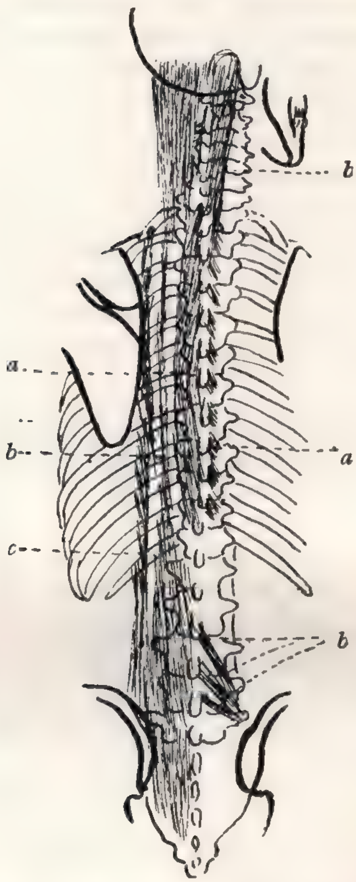


FIG. 42.—The deep muscles of the vertebral column (after Stibbe).

"These muscles, which bend the vertebral column, include not only those inserted into the vertebræ but certain longitudinal muscles inserted into ribs near the vertebral column, and some partially inserted into the back of the head.

All these muscles may conveniently be divided into three groups:

(a) Short muscles between adjacent vertebræ. These are rotators (ROTATORES), and lateral flexors (INTERTRANSVERSE MUSCLES). They are the deepest of the series.

(b) Muscles running obliquely from transverse processes below to spines or laminæ above, missing several vertebræ between origin and insertion. These are: the MULTIFIDUS, which misses one or two vertebræ and is placed immediately, superficial to the rotatores; and the SEMI-SPINALIS, which misses four to six vertebræ and lies superficial to the multifidus. *These two muscles combine extension with lateral flexion and rotation.* Part of the semispinalis is inserted into the back of the skull.

(c) Superficially placed longitudinal muscles with a long interval between origin and insertion, and the principal action of which is extension of the spine, while certain of them also laterally flex the spine. These muscles are known collectively as the SACRO-SPINALIS, because they have an extensive common origin below. From the common origin three columns arise: the medial or SPINALIS (spines to spines); intermediate or LONGISSIMUS (common origin to transverse processes and ribs); and the lateral or ILIOCOSTALIS (common origin to ribs near their angles). Special slips of these muscles are continued up into the neck."

to the Chartered Society on the subject of scoliosis and the importance of strengthening the intrinsic muscles of the vertebral column when treating this condition.

MANIPULATION : SACRO-ILIAC STRAIN

The aim of the physiotherapist when treating sacro-iliac strain is to relax tense structures and then to restore normal movements to all joints, especially in the lumbar region ; and to follow this mobilization by direct strengthening work to the muscles which cross the sacro-iliac joint. These are chiefly gluteus maximus, the pyraformis and the lower lumbar muscles, latissimus dorsi and the abdominal muscles.

Suspension will remove *all weight and strain from the actual articular surfaces* and the amount of work can be graded from a minimum to a maximum. Relaxation is a most important preliminary to the treatment.

The patient should be suspended in side-lying, both legs suspended from a single sling, and taught to relax and get used to the position. Then the physiotherapist lowers the shoulders and head of the patient and very gently swings the body and legs to and fro in tiny movements, to test the degree of relaxation ; at first, carefully supporting the part to be mobilized. The first few treatments will follow on these lines until the patient " lets go " and muscle tension is relieved ; then movements are carried out in ever-increasing doses of passive or assisted-active movement. All the movements must be isolated and localized by the physiotherapist. This treatment will achieve the first aim—relaxation and mobilization.

Muscle-strengthening exercises must now follow, and be of the assisted active type : the patient will follow the movements as started by the physiotherapist, and swing the buttocks to and fro, until the muscles are stronger ; progressing to large and strong movements ending in " holding " exercises—first in flexion, then in extension. For still further progression, manual resistance with one hand can be given over the knees while the other hand steadies the " anchored " part of the body. (See Fig. 43 of Flexion and Fig. 44 of Extension.)

Further exercises

(1) *Side-lying* single leg hyper-extension. This is a useful position as it localizes movement to one sacro-iliac joint—the uppermost leg is moved, the other is anchored on the plinth.

(2) *Back-lying* (head and shoulders anchored), legs in crook and strapped together. This is the best position in which to get

FIG. 43.—Flexion. An assisted-active movement.

lateral movements of the spine and sacro-iliac region; the feet should be supported as well as the knees.

(3) *Prone-lying* on couch, introduces gravity as resistance; strong hyper-extension is obtained as the head and legs are raised from the couch, the erector spinæ will be worked in its inner range. (Fig. 180.)

(4) Fig. 45 illustrates good static abdominal work to strengthen the abdominal muscles, in the Swedish exercise of trunk-backward-falling.

(5) Trunk rotations of the quick-change-twisting type can be given free, or with a pole grasped behind the shoulders while the patient sits in a stride-stoop-sitting position.

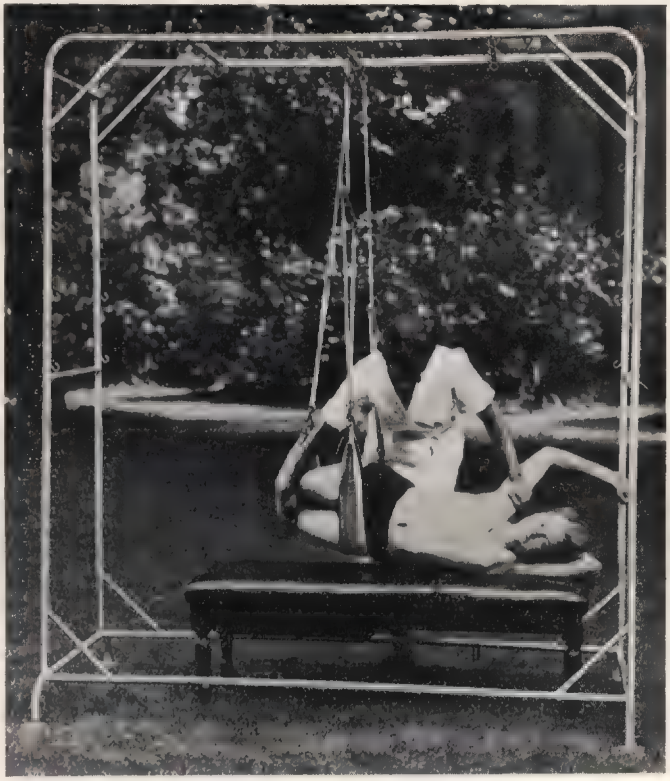


FIG. 44.—Extension. Side-lying head and shoulders anchored, legs crooked and strapped together, the operator's knee supports the back for assisted-active extension movements.

(6) The gluteus maximus must be made as strong as possible, therefore the muscle should be worked in its inner range, against strong and increasing resistance. (Figs. 134 to 138.)

Other useful exercises will be:

(7) Pelvic tilting, in varied starting positions. (Figs. 101–102.)

(8) Hip joint mobility exercises, to obtain full mobility of both joints. (Figs. 134–138.)

(9) Abdominal contractions, in all ranges of movement—diagrams of these exercises will be found in the chapter on "Regional Exercises." (Figs. 94–95.)

Strong, free exercises should conclude the treatment so that patients may be discharged fit and strong and ready for any work.

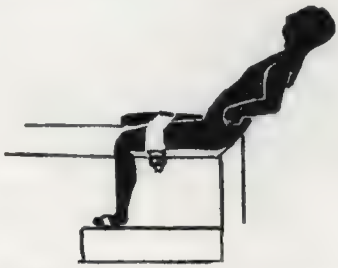


FIG. 45.—Wing high-ride-sitting trunk backward falling.

Rotation exercises of the lower part of the trunk with the shoulder and arms fixed are very suitable free exercises for this condition. A full description and illustration of such exercises has been contributed by Mary Littlewood, M.C.S.P. Her article should be studied so that suitable exercises can be selected which will restore the patient to his "former condition." (Chap. XVIII.)

CHAPTER VIII

JOINT MANIPULATION

By JAMES MENNELL, M.D. Cantab., etc., Consulting Physico-Therapist, St. Thomas's Hospital, London, and one time Chairman of the Council of the Chartered Society of Massage and Medical Gymnastics.

The main objective in compiling the present volume has been to draw attention to the extraordinary value of re-educating joints and muscles that have been incapacitated through injury or disease by movement when the action of gravity has been eliminated. To a very slight extent this is possible by movement in ordinary plain water, and still better by under-water movement in sea water, but at Droitwich alone, in the brine bath, is the action of gravity entirely eliminated. Unfortunately a course of treatment is of necessity confined more or less to three weeks, which is far too short a time to give full benefit to joints that have been seriously impaired, or for muscles to make an adequate recovery when the loss of power has been very marked.

By means of the independent use of Mrs. Guthrie-Smith's sling-suspension apparatus, not only can the action of gravity be eliminated, but resistance can be added by imperceptible stages, as muscle strength and co-ordination of movement are restored gradually, and there is no limit to the length of time through which the treatment can be carried out. Therefore it is plain that this is one of the great hopes that we can offer in the advance of physical treatment for patients who would otherwise continue with indefinite incapacity.

There is, however, one point to which the present chapter will draw attention and which, in the past, has been only too often overlooked, and that is the futility of trying to restore strength and activity to muscles when the condition of the joints is such that it is impossible for muscles to move them adequately and with freedom. There can be no doubt that joint and muscle movement are so correlated together that either must be imperfect if the other is impaired. Then it is essential to remember that this correlation

is dependent on the integrity of the muscle, tendon and joint senses, the centres for which, being somewhat late in developing, are all the more easily upset by outrage in the form of illness or injury, or as the result of disuse.

When a muscle is not up to its normal strength, it is manifest that control over the movements of a joint in a state of perfect preservation must be limited, but it follows as a necessary sequence that if for any reason the movement of a joint is impaired, a weakened muscle must, of necessity, have still less control. In addition there is a definite reflex which is directly connected with the instinct of self-preservation. This instinct is by no means confined to the preservation of life, but operates equally when it comes to a question of preservation from pain and discomfort. Hence it comes about that, if a muscle is performing movement, and if the muscle becomes conscious that pain will occur should further movement in a joint take place, the muscle will, by reflex, cease to contract before the joint has reached the position at which pain will occur, and so control and co-ordinated movement are lost. It follows, therefore, that an essential precedent to the return of full muscle function is restoration of full joint mobility.

The loss of function within a joint may be due to many causes, and amongst them are, first of all, gross bacteriological change within the joint, in the peri-articular tissues, and in the muscles or in the fibrous tissue within and surrounding the muscles in the neighbourhood of the affected joint. When a joint is stiff through disuse, it does not, of necessity, mean that any gross bacteriological change is present in the joint or peri-articular tissues. It is perfectly true that the fibrous tissue in and around the muscles is of the white fibrous variety, and is entirely devoid of yellow elastic tissue. Hence, strictly speaking, this white fibrous tissue is not elastic, and when movement of a joint is limited, through what appears to be lack of elasticity in the muscles which control the movement of the joint, it is not really due to loss of elasticity but possibly to actual shrinkage or, more likely, to loss of adequate mobility.

Restoration of mobility to fibrous tissue and overcoming of any shrinkage which may have taken place, is, as a rule, the

function of treatment by massage and voluntary muscle movement. Graduated faradic contraction may sometimes play a part, but it is a minor part when compared with the other remedies. The main function of faradism in dealing with conditions of this nature is to re-educate the muscle and tendon senses, as it not infrequently happens that patients literally forget how to move their own muscles and what it feels like to have them moving again after prolonged disuse.

Just as fibrous tissue in and around the muscles can be affected by injury, disease or prolonged disuse, or by a combination of any two or of all three together, so too the peri-articular structures can suffer in exactly the same way. As already stated (though contrary to what is often thought) there are no true elastic fibres in the ligaments in and around the joints of the body (except in one situation in the spinal column) ; they consist absolutely and entirely of white fibrous tissue which is inelastic. But, although inelastic, adaptive shortening takes place, even in the complete absence of injury or disease, merely as the result of joints failing to move through their full range of movement over a considerable space of time. After injury, or in the presence of bacteriological infection, these changes may be, of course, magnified to a very wide extent. When bacteriological changes have been present either within the joint or in the structures surrounding it, definite adhesions are liable to form. These not only interfere with the movement of the joints, but often enough, when tension is laid upon them, pain is caused. Pain, as we well know, is a sign that something is happening within the body which should not be happening, and the result of this is usually that an inflammatory process will be set up. Thus it comes about that this inflammatory reaction is really adding to the bacteriological condition which is already present, so that the patient slips steadily downhill. Take, for example, the patient who comes to us with a stiff shoulder ; the only history, very often, is that whilst strap-hanging or holding on to the handle of a bus which gives a sudden jerk a strain is felt upon the shoulder, and nothing more is thought about the matter. Still, the strain has been sufficient to cause a slight inflammatory condition within the joint, and as very few of us put our shoulder joints through their full range of movement in an ordinary way,

adhesions begin to form during the recovery from the traumatic arthritis. The limitation of movement, which is negligible, is often quite unnoticed by the patient. At long intervals, however, the range of movement is performed which irritates the adhesions. These increase in quality and in quantity, a few more degrees of movement are lost, until the range of movement which causes further irritation becomes one which is in more daily use. The irritation thereupon becomes more frequent and painful, and the downfall is marked by geometrical progression, until at the end of a few months gross limitation of movement and often enough severe pain are alike present. There are, of course, a certain number of more or less heroic individuals who can sometimes succeed in restoring mobility even when it is lost to a very wide extent, but it calls for the exercise of a very considerable amount of perseverance and disregard of pain and discomfort, which few people are willing to undergo if any other method of treatment is available. Even at the very best, their efforts are often unsuccessful, and not uncommonly do a great deal more harm than good. If fibrous bands are present which impede movement, then it is obvious that the short cut to recovery is to break them across and then to treat the joint as one which has sustained a severe recent injury, namely, to encourage and to assist all movement that can be performed without pain constantly throughout the day, and once a day to put the joint through a range of movement which is the widest possible that can be accomplished even with some pain. The maximum frequency of movement that should ever be allowed when pain is caused should be limited to once a day. This allows some twenty-four hours for the reaction to subside; if at the end of that time it has not subsided, a further period of rest should be given to allow it to do so.

Another somewhat valuable, but rather arbitrary, rule is that pain on movement is not deleterious, provided that any pain or discomfort caused by it subsides within half an hour of the patient being placed at rest. If any discomfort continues beyond this limit it may be taken for granted that too much has been attempted.

We now pass on to much more controversial matter, and that is the question of whether it is possible for imperfection of joint movement to exist in the absence of any demonstrable pathological

condition within or without the joint. There seems to be every reason for supposing that this is so, though it is only in comparatively recent years that evidence has been forthcoming to prove it. While we had to rely for our knowledge of joints and joint movement on such as we could obtain in the dissecting room, it seemed very doubtful whether the claims made by those who practise joint manipulation were in any part justifiable. When, however, by means of X-ray examination it became possible to examine the living anatomy of joints, a definite change of outlook became necessary. Let us take, for example, a patient who complains of pain on movement in the neighbourhood of the wrist. It used to be considered that dorsi-flexion and palmar-flexion of the hand took place at the wrist joint, *i.e.* the radio-menisco-carpal joint. We now know that the movement of palmar-flexion takes place largely at this joint, whereas the movement of dorsi-flexion is almost entirely confined, or at any rate is very largely concerned, with movement at the inter-carpal joint, *i.e.* at the joint between the two rows of carpal joints. So, too, the old description of the anatomical movements of the shoulder joint are described almost in identical terms as those of the hip joint. Yet it is manifest from a study of the shape of the glenoid and acetabulum that these two joint surfaces bear no similarity to one another. This can only mean that, however similar the movement may appear to be at first sight, it must, of necessity, be very dissimilar. It is quite easy to establish that this is so in normal physiological movement, as in every movement of the shoulder the head of the humerus not only rotates on the glenoid but actually performs a definite gliding movement. At the same time, in any movement of the hip joint this gliding movement is entirely absent in normal life, though to a limited extent it may take place when very advanced pathological changes have taken place.

Another point which the study of the living anatomy of joints established as quite definite is that, although under the old régime movements were described which were normally under voluntary control, no reference was made to those which are not under voluntary control. The most important of these is tension. Perhaps the most striking example is to be seen in the radio-ulnar joints, where it can be demonstrated beyond all question that the

radius has a small range of free mobility in an upward and downward direction in the forearm, as the radius has no attachment to the humerus. Any strain that pulls the radius too far downward (the "pulled elbow"), or any force that pushes it too far upward (the "pushed elbow"), is liable to produce the most distressing symptoms, with loss of mobility. The pulled elbow can be restored to function by pressing the shaft of the radius upward; the pushed elbow can be dealt with in a similar manner by tension pulling it down again.

There are movements at almost every joint in the body which remain unsuspected until study from the point of view of living anatomy and physiology has been made, and so it comes about that a large number of true joint "lesions" have previously been overlooked. For instance, after injury to the wrist region, pain will often persist, with no obvious sign of loss of joint movement, until the mobility of the intercarpal joints is examined. Then it may be found that one of the carpal bones is not moving freely on one or more of its neighbours, and the obvious and only remedy is to restore the lost mobility. Herein rests the secret of the instantaneous "cure" that so often is possible after injury at tennis or golf.

Controversy has always raged around the movement of the sacro-iliac joint, which is usually described as a synchrondosis instead of being a movable joint, which the presence of an ordinary joint surface clearly indicates. That movement does take place can be established by measuring the distance between the posterior superior spines of the two ilia in the sitting and prone positions. In a reasonably mobile subject the gap diminishes by anything up to half an inch when the patient lies on the face. Whether we consider that this is due to rotation of the ilia on the sacrum or of the sacrum on the ilia is immaterial. The fact remains that movement has taken place. This movement is of course rotatory, and it is plain that many factors are involved in the normal movement of the joint. Thus, if there is any lack of normal elasticity in the hamstrings the ischial tuberosity is anchored by them in the stooping position with the knees straight. If this movement is then forced, undue strain must inevitably be placed upon the joints in the form of backward torsion strain. Hence it comes about that the prohibition of the forward-bending to touch the toes,

when performing the "daily dozen," is often the best remedy for relieving strain on these joints, with the resulting relief from symptoms; and so the story can be carried on indefinitely concerning almost every joint in the body.

The next consideration is that of the symptoms that might be reasonably expected to arise as a result of this comparatively new knowledge. In the first place we have to consider two main points:

(1) Is it possible for a joint to have disordered function without pathological change being visible on X-ray examination?; and

(2) The problem of referred pain.

Radiologists as a whole are extremely cautious in giving a diagnosis as to the result of their examination of joints, and confine themselves as a rule to saying that the photographs show no evidence of injury or disease. This does not mean by any means that injury or disease, or possibly both, are not present. There can be very little doubt that the function of a joint can be seriously incommoded without any demonstrable alteration in the relationship of the joint surfaces as ordinarily examined. This, however, does not necessarily mean that, if they were examined in positions approximating to the full limit of movement, some abnormal relationship could not be established. It is the correction of these minor faults and relationships which render the so-called "miracle cure of the bone-setter" a real and striking possibility. As an example let us take the trouble that is frequently felt over the lower end of the fibula as a result of a sprained ankle or a fracture of the external malleolus. The spring of the fibula has been subjected to a severe strain; at the lower end the junction with the tibia is confined entirely to a ligamentous union, but at the upper end there is a joint surface with a joint cavity where movement must of necessity take place. In other words, the upper end of the spring is free to move and thus to save the spring from undue strain. But for this freedom of movement at the upper end fractures of the shaft would be incessant as the result of minor injuries. If, however, the spring is subjected to undue tension, the movement of the joint at the upper end may well be

pushed beyond the limit of physiological movement, and so the two joint surfaces become bound together with no freedom of movement. There may or may not be a certain amount of pain in the neighbourhood of the knee joint, but in the absence of movement at the upper end of the spring, pressure laid upon the lower end will inevitably cause pain, owing to the lack of freedom of movement due to the loss of mobility higher up. Treatment which aims at relief of this pain without freeing the mobility of the superior tibio-fibular joint is doomed to failure.

The same also applies to practically every joint in the body, but two of those that are commonly overlooked are the costo-vertebral and costo-transverse joints. The movement of the ribs around these joints is immensely complicated. The joints are small, but the leverage on the ribs from their front parts is very considerable and the muscles attached here are very powerful Hence it comes about that, under extraordinary strain, one or more of these joints may be pulled to a limit which passes the ordinary physiological range, the rib becomes locked, and nothing but restoring mobility will relieve the symptoms arising from the lack of it. After all, it is not unlikely that X-ray examination should fail to reveal any alteration in the joint surfaces any more than it can reveal the alteration, say, between two carpal bones or in the minute joints at the bases of the metacarpal bones. The nature of these so-called "lesions" varies with each joint, but disordered function remains.

Now to refer to our second point, the question of the referred pain. It has long been acknowledged that if a patient complains of a pain in the knee joint and nothing definite can be found, the next thing to do is to examine the hip joint, as early arthritis of the hip is constantly revealed by pain in the knee in the earliest stages. So, too, pain in the right shoulder region has long been associated with an attack of biliary colic, and pain in the left arm with angina. If we accept the fact that trouble in the hip joint causes referred pain in the knee, it seems irrational to suppose that referred pain should not be felt when other joints are affected. We all of us know that if we pinch the tip of a finger sufficiently hard to cause a blood blister to form beneath the nail the pain at the time of the accident is by no means confined to the finger, but shoots right up the arm. So, too, if two joint surfaces form a faulty

contact the pressure of the two cartilages together, or the nipping of a synovial pad between the two surfaces, can reasonably be supposed to cause pain to radiate. Keeping only to the examples already quoted, the pain radiating from a shoulder that does not function properly is often described as a "brachial neuritis," and this is by no means solely confined to cases in which definite adhesions are present. If, for example, the arm is allowed to hang by the side, with the deltoid inert and inactive, it will lose its power of control on the stability of the position at the head of the humerus in the glenoid. This allows the head of the humerus to drop downward till the convex surface of the bone rests upon the lower edge of the glenoid. This point, being unaccustomed to continual pressure, becomes sore and inflamed, and the only remedy is to push the head of the bone upward towards the acromion and support it there by a sling under the olecranon. This remedy is often sufficient to relieve a very intractable attack of so-called brachial neuritis. When the strength of the deltoid is sufficiently restored by faradism, exercises, or both to support the weight of the limb, the so-called "neuritis" is permanently cured.

Pain referred from the costal joints is usually called a pleurodynia. Most cases of this distressing malady are traumatic and not rheumatic. The pain is referred around the chest wall when any of the joints below the second is involved, and then, lower down, it may be referred over the abdominal wall, and it must also be kept in mind that pain may similarly be referred from corresponding disturbances of function in the intervertebral joints. Thus it comes about that in the upper region the sensation of pain may be transferred through the grey ramus from the superior thoracic ganglion to the outer side of the upper arm over the deltoid region. Lower down, pain in the chest wall is very readily mistaken for pain in the structures superficial to it or deep to it. Thus, pain in the region of the breast may very easily be mistaken for a mastitis, or, on the left side, for trouble in connexion with the heart. Lower down, pain in the abdominal wall over the gall-bladder may be mistaken for trouble within the gall-bladder, and on the other side pain over the stomach may be mistaken for trouble in the organ itself. Lower down in the right iliac fossa, pain in the ligaments on the front of the sacro-iliac joint is situated

in a normally thin person only half an inch away from McBurnie's appendicitis point. So it comes about that often enough the removal of an appendix does not cure the pain in this situation. From the sacro-iliac joint pain is liable to radiate over a very wide area, and symptoms arising from pain within this joint are very commonly attributed to sciatica. And so the story runs almost indefinitely from the occipital joints from which symptoms may approximate so closely to a true migraine that they are quite indistinguishable from it. True migraine is incurable by manipulation, pseudo-migraine is curable, and from every joint downwards to the coccygeal joints the same tale can be told. Yet it is perfectly plain that if a patient owes symptoms to disordered function within a joint nothing but restoration of the normal function can relieve the symptoms. This is the part played by manipulation.

As far as manipulation is concerned, the technique varies with each individual joint, but there are a few laws which govern the technique for the manipulation of all joints. The first is to place the patient in the one position in which the joints are free to move through their full range. For instance, it is utterly impossible, even in a perfectly normal subject, to rotate the head to right or to left to the same extent in the sitting position as is possible in the recumbent position. Indeed, for the most part it is in the recumbent position that most joints can receive the full benefit from manipulation. The second essential is to find out what limitation, if any, is present in those movements which are not under voluntary control as well as the limitations of the movements that are under it. At every joint in the body it is possible to perform some movement which is not under voluntary control, and the one outstanding example is tension. Yet this simple movement alone is often all that is required to restore perfection of function, even though it may have been lost to a serious extent. There are, however, at almost all joints other movements which are similarly not under voluntary control and which yet can be performed as a result of impressed force from without the limb. Having freed these movements which are not under voluntary control, then, but then only, are we justified in passing on to those movements that are under voluntary control.

In performing these movements there are certain laws which must be rigidly observed, and the most important is to " take up the slack," by which we mean that the joint must be moved to the utmost limit before any impressed force is exerted upon it. The force then exerted must be in the nature of a thrust which should only be administered after complete relaxation has been secured. It is obvious that perfect control must exist while this force is being applied or we may unwittingly overshoot the mark and so do more harm than good.

Next, in order to move one joint surface upon another it is obvious that, if control is to be perfect, the joint surface on one side must be rigidly fixed while that on the other side is moved upon it. It is this difficulty of securing adequate fixation of the one side that presents the most difficult part of our problem. This applies particularly to the joints of the vertebral column.

Needless to say, the thrust or pull which serves as a corrective force must be exerted only in the direction that will free a mobility which has been lost. It must also be administered in such a manner that the moment the lost mobility has been restored the movement shall cease.

Considering the undoubted fact of the extraordinary number of well-substantiated " cures " of symptoms as the result of manipulative treatment, it is remarkable that the art of manipulation has not yet formed a definite part of the education of students during their normal course of training. Until the day comes when all medical students are taught the possibilities of this treatment, so long will the " quack " practitioner of manipulative work continue to flourish, and cults of various denominations and creeds outside the profession will reap not only the financial benefit but earn the lasting gratitude of their patients. It is, of course, perfectly true that those among them who have only one egg in their basket are doomed to failure, that occasionally bodily harm, and sometimes grievous bodily harm, is done, and few of us would be willing in a reputable profession to carry on with a treatment of which this can be said. Still, with reasonable care, treatment by joint manipulation has so far advanced that the risk of injury is now almost negligible in proportion to the benefit that so often accrues from it.

CHAPTER IX

PULLEY THERAPY

For purposes of rehabilitation and remedial exercises pulleys are used in two ways, or systems :

(1) Pulley-and-rope system—a reciprocal pulley system.
(2) Pulley-and-weight system.

PULLEY-AND-ROPE SYSTEM FOR AUTO-ASSISTED EXERCISE

There is no simpler device than a pulley-and-rope, yet how effective it is for altering the direction of force. A boat sail can be held and adjusted to the finest degree of variance by a person handling the sail through the medium of a rope and pulley. One realizes what a marked advantage that person has acquired over the forces working against him, because he can control the effect of the force.

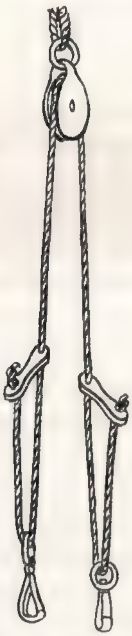


FIG. 46.—Simple pulley-and-rope outfit.

A schedule of exercises using a pulley and rope for all the chief joints of the body has been worked out, and will be found to give a similar advantage. For remedial purposes, a patient by using a pulley and rope outfit which is suspended from an overhead beam acquires an ability to overcome forces which work against free movement ; added to this, the effect of the force is under his own control. The application of these exercises is therefore of particular service for the treatment of stiff joints.

STIFF JOINTS AND THEIR MOBILITY EXERCISES

Stiff joints are usually due to sepsis, disuse, or to a lack of activity in the early stages of treatment ; this inactivity results in the consolidation of adhesions. Adhesions are formed by exudate from torn structures damaged at the time of injury ; a sero-fibrinous exudation may pass in to all the tissue spaces if there has been

a lack of active movement. This exudate can organize and actually " glue up the joint."

Any injury to a joint leaves a feeling of weakness and pain ; the patient becomes " joint-conscious." This means that if the injury or disease is in the region of the lower limb the subject will try to " save it " consciously or unconsciously, and by so doing may develop " a gait " or limp which is undesirable ; this tends to put a strain on other structures and upsets the normal mechanics of the body.

Such a result of subacute pain is often seen among chronic out-patients of an osteo-arthritic type. These people commonly develop a rolling gait, the muscle work being that of hip and trunk and not of the knee at all. As a consequence the treatment given to them is of little use unless they are taught the use of their quadriceps muscle, not only in remedial exercise, but when standing, walking and feeling the full weight of the body. The walk home should be of remedial value and should carry on the good work done in the department.

Joint pain and ultimate stiffness may lead to much functional disability ; in fact, it is possible that in every disability there is a very large functional element. Bearing this in mind, if the full range of movement has not been carried out in the early stages, the patient forgets how to perform certain actions, *muscle consciousness* is lost, the muscles themselves become inert and atrophy ; the fibrous structures then tend to contract through lack of being stretched, and the tension-strain due to these factors leads to pain. The patient dodges the painful movement, develops trick movements, and functional defects are superimposed upon the actual disability, and may in fact be even more difficult to eradicate.

A good deal of thought must be exercised to obtain movements which will elicit the patient's co-operation in all the different joints of the body. In designing exercises for stiff joints, ingenuity and subtlety are required to prevent the patient—because of pain, or fear of pain—from inhibiting his own movements.

In these days a patient is no longer told to carry about with his injured arm buckets of water, suit-cases, etc., in order to straighten a stiff elbow, due to a contracture of the biceps tendon. Such

measures only result in disaster and pain. This pain can only be relieved by "muscle guard," therefore the contracture will tend to be aggravated and intensified. It is a much sounder policy to apply the *principles of reciprocal-innervation*; to activate the joint by extending the elbow with the action of the antagonists group of muscles (the triceps). The familiar punch-ball exercise is a good example of this movement.

It is for this reason that a series of mainly auto-assisted mobility exercises are suggested, so that the patient will gain confidence and gradually increase his range of movement and his muscle power at the same time.

After all, there is no substitute for a strong muscle; if the muscle is destroyed the ligaments are quite unable to stabilize a joint, therefore every type of treatment should be instituted to save a muscle and to "assist" its work; also to promote a stretching of the tight fibrous elements, and, above all, to induce relaxation—particularly the relaxation of the antagonist muscles.

I. PULLEY-AND-ROPE SYSTEM *

Rehabilitation exercises with the aid of pulley and rope are now in daily and constant use in the Massage and Fracture Clinic departments of St. Mary's Hospital, W.2. They have proved over many years an invaluable help in the constant problem of restoring movement and function to the injured.

These exercises were originally thought out by the author to cope with the stress of work on wounded men in 1916 and the following years. Old neglected stiff joints after septic infections were then the order of the day, and 80 per cent. or more of our work was an attempt to restore function to such damaged structures.

The injured man appreciated the activity which this method demanded of him, and seemed to prefer to hurt himself if necessary rather than to be hurt! His logical and stoical mind soon appreciated the mild mechanical forces applied by the "pulley and

* Part of this chapter was published March, 1940, in the *Journal of the Chartered Society of Massage and Medical Gymnastics*, and four of the blocks have been kindly lent by the editor of that journal.

purchase," and he became interested in the treatment. On the other hand the physiotherapist found her work much lightened by his co-operation and interest, and we were delighted in those difficult times to find a method of treatment which was practically fool-proof and not too painful.

Auto-assisted Movement

The effect of the exercises on joints.—The keynote of this form of exercises is to make the *patient co-operate in his own cure.* The movements are performed entirely by the patient himself, but under the supervision of a skilled operator. It is an interesting fact that owing to the slight muscle work required, a selective effect is obtained upon the joints and their structures ; this can be increased by the amount of self-traction that is given. Since much repetition is possible without fatigue, these exercises will help to restore normal controlled movement. Considerable co-ordination is required to perform the exercises smoothly and to keep the rope-circuit taut. This is particularly true of the spinal exercises, in which the whole body must be held in a good position while the trunk is being rotated or side-flexed.

The exercises are all double-sided and the movements can be reciprocally opposed. When the injured part is carried by the momentum of the alternate action past the " point of pain " which the patient dreads, he will accomplish more than he ever thought possible. This subtle effect is clearly demonstrated in *Functional Conditions.* For these cases the chosen movements should be quick, small and rhythmical, in an ever-increasing range ; this tends to confuse the patient's sense of position of the limb in space, and lessens the chance of the movement being inhibited. The real disability and limitation, if any, are therefore more clearly discernible.

(Fig. 46.) The to-and-fro movement of the rope through the pulley-block is easy and rather fascinating to perform, and the gentle rhythmic muscle-work will relieve spasm and tremor and promote relaxation. It is dangerous to force joint movements, and it is much wiser to let the patient do the movement for himself. Then any pain is self-inflicted and under the patient's own control.

All joint movements, whether passive or active, have a *circulatory effect* owing to the compression and stretching of the blood vessels over the joints.

Technique

A clear therapeutic aim for assisting the patient's movement should be thought out before adjusting the apparatus.

(1) **The relative position of the pulley and the patient.**—Both pulley and patient must be arranged carefully to get the required traction. The pulley must be either forward, above, behind or lateral to the body, and if these details are gone into with care a great variety and degree of stretching can be obtained, including excellent rotation exercises for both shoulder and trunk.

(2) **Starting position.**—It is necessary to understand the importance of a *taut rope.* In an exercise for the shoulder, for example, the injured limb will be placed in the " bend " position, which allows for comfort and an easy start, while the sound limb is in a full " stretch." As the good arm descends it drags the other arm up by its weight, but if there is slack in the rope the whole effect is lost.

(3) **The patient's position** should be based upon sound Swedish remedial positions—*e.g.* half-lying or high-ride-sitting if it is necessary to fix the pelvis. If this good starting position is not insisted upon a bad type of movement may result, with " dodging " of the important part of the exercise.

(4) **Personal supervision** of these points is essential. Too many physiotherapists tell the patients to " carry on " ; this nearly always results in bad gymnastics.

These exercises can be done in three ways.

(*a*) **Passive movement.**—The good limb may do all the work, and the injured one is pulled up and returns by its own weight, controlled by the good limb through the rope circuit. This is usually the first and easiest exercise to perform for patients with recent and painful injuries.

(*b*) **Active bilateral movement in small ranges** done with rhythm and counting : this reduces tension, and the range of movement can be gradually increased as the pain decreases. It is invaluable for tense, nervous people.

(*c*) **Active energetic action** getting full range movement in the injured limb. Then the " good " limb will give overstretching to the weak one by its weight, and will help to get the powerful thrusting work which will restore free movement. " Holding " movements in the maximum stretched position are also good. The co-ordination required for the alternate thrusting movement is not easy to learn and must be closely supervised. This type of work is a strong progression on the former exercises.

(*d*) **Self-resisted movements** can also be carried out.

Model Exercises in Treatment

(1) **Arm exercises.**—(*a*) Half-bend, half-stretch, stride-sitting; alternate arm changing (Fig. 47). Position A of the pulley is the easiest, since the traction is only given in a forward and upward direction. Position B of the pulley is a progression, since the traction is in a vertical direction. The arrow on the forearm illustrates the method of passive movement, while the arrow beneath B suggests an active upthrusting.

(*b*) The pulley may be placed behind the patient, provided that he is in the half-lying position. This gives a good backward traction. Slight rotation of the shoulder joint may also be obtained if the forearm is fully pronated. (Fig. 51, B.)

(*c*) Another starting position is yard half-lying, in which the sound arm will be actively pressed down, thereby moving the injured limb from abduction to an elevated position. The best movement will be obtained if the pulley block is placed directly over the injured shoulder.

(*d*) Half-stretch, half-bend, lying supine on a high-ride sitting plinth, fixes the whole body and gives a maximum exercise for elevation, with rotation. The arms should travel in the plane of the plinth. (Fig. 51, C.)

(*e*) An outward rotation exercise for the shoulder is illustrated in Fig. 48. The high-ride-sitting position has been chosen because it is a good gymnastic position and fixes the pelvis. The dotted line indicates the starting position for obtaining inward rotation of the arm.

All this series of arm exercises will be found invaluable for the

treatment of stiff shoulders, old fracture cases and traumatic injuries.

(2) **Leg exercises.**—(*a*) Prone-lying on a sloping couch, alternate knee stretching. This is illustrated in Fig. 49. The raised angle of the couch is an essential element to gain full movement of the knee joint and the overstretching action which is obtained

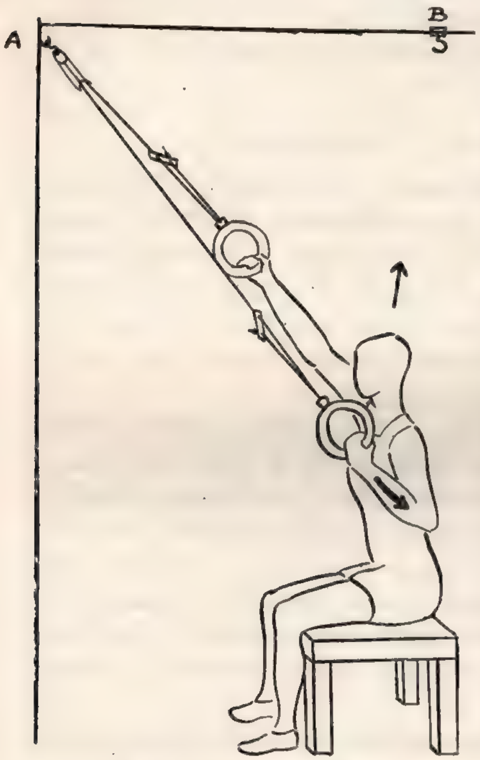


FIG. 47.—Shoulder exercise.

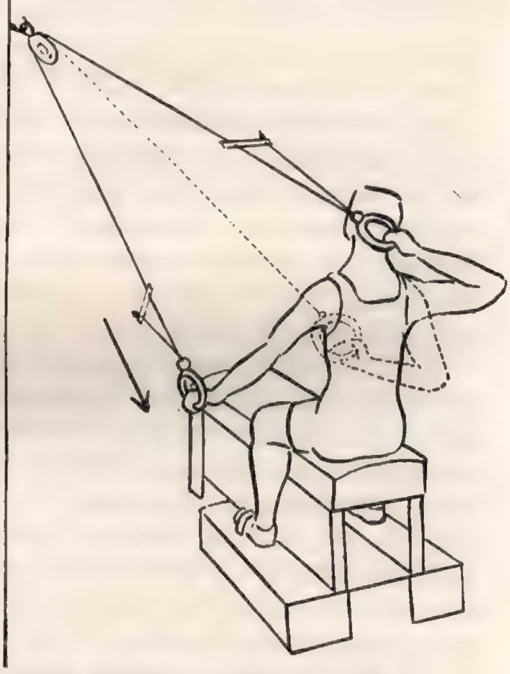


FIG. 48.—Shoulder exercise for outward and inward rotation.

by the use of a rope circuit. It is a good gymnastic position, since all other joints except the knees are immobilized. Alternate downward pressure of the legs will produce good quadriceps action in the full range of movement. This exercise will be found most useful in strengthening weak muscles around the knee and in obtaining flexion mobility for such conditions as an old fractured patella or after an operation for a displaced cartilage.

(*b*) With similar apparatus to that shown in the last exercise, but with the pulley raised about 4 ft., a hamstring-stretching exercise can be performed in back-lying, starting with one hip fully flexed and the other fully extended. (Fig. 52, A.)

The legs are alternately pressed downward working the extensors of the hips and the extensors of the knees and spine in association with each other.

(*c*) The legs can be alternately raised, using the flexors of the hip joints associated with strong *abdominal contractions*. The rope

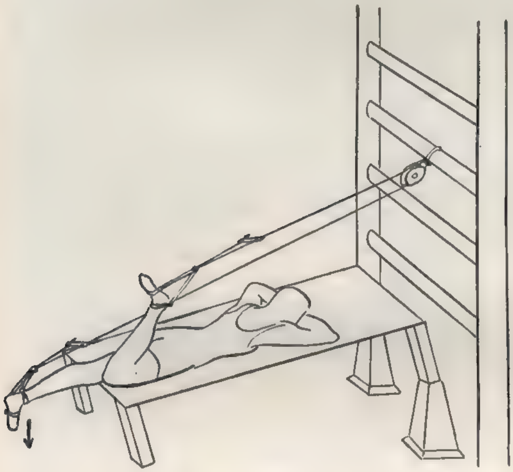


FIG. 49.—Knee exercises.

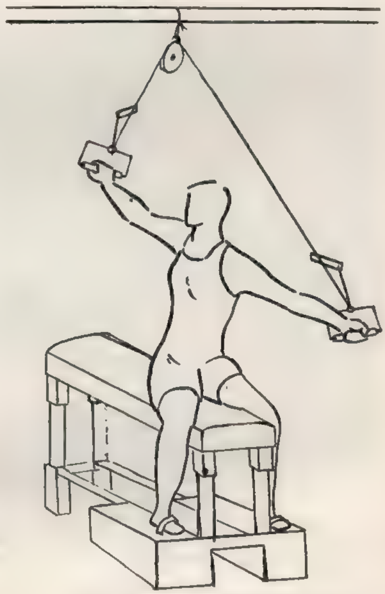


FIG. 50.—Trunk exercise.

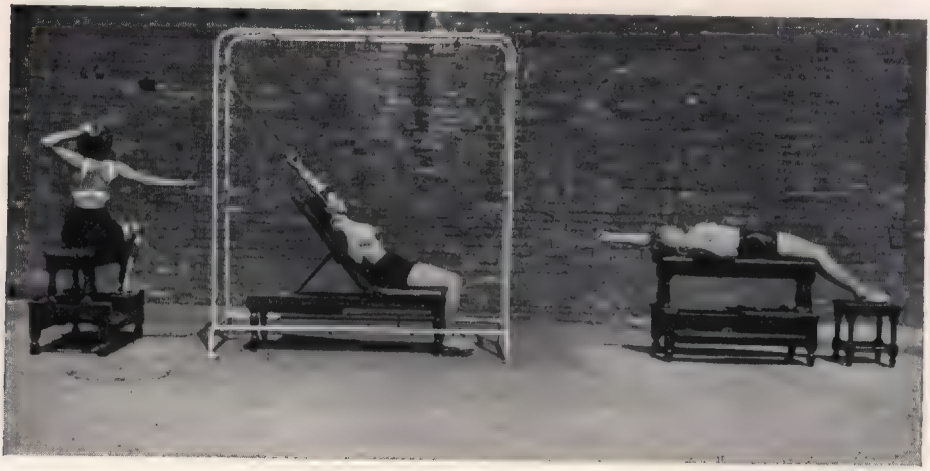
must be kept taut, as the exercise is performed against gravity and therefore involves considerable co-ordination.

(*d*) Leg changing can also be performed with flexion of the knees as well as of the hips: in back-lying this results in modified leg cycling, with abdominal work in fixation.

(3) **Trunk exercises.**—(i) *Spinal mobility.*—(*a*) Yard-grasp, stoop high-ride-sitting, quick change twisting. The pulley is placed behind and above the patient. This is a useful method to obtain mobility of the spine through trunk rotation, and works the oblique abdominal muscles strongly. The exercise must be

carried out with smooth swinging movements so that the trunk is alternately twisted to the right, and the left, while the arms are kept strictly in the yard position. All this involves considerable co-ordination. With this simple apparatus a useful exercise ensuring localized mobilization of the spine can be given. (Fig. 50.)

(ii) *Stretching of the thorax*.—(*b*) Side-flexion exercises are also easily carried out and make a useful variety in treatment. The patient is placed in yard-stride-standing, with the pulley-block to the side towards which the bending takes place. These exercises



A B C

FIG. 51.—Group exercise, using simple pulley and rope. The photograph illustrates shoulder work, and how to supervise three *different* exercises at one time.

Suspension frame used as a portable gymnasium.

give the most powerful stretching movements to the ribs, and intercostal muscles, as well as to the spine itself, and are indicated in surgical, or medical cases, where mobility of the spine or chest is required. (Fig. 99.)

SUMMARY

(1) Bilateral pulley exercises, owing to the good traction produced, have special effects on joints and their structures.

(2) The alternating motion involves only slight muscle-work, but good co-ordination of movement ; muscle power and mobility grow together.

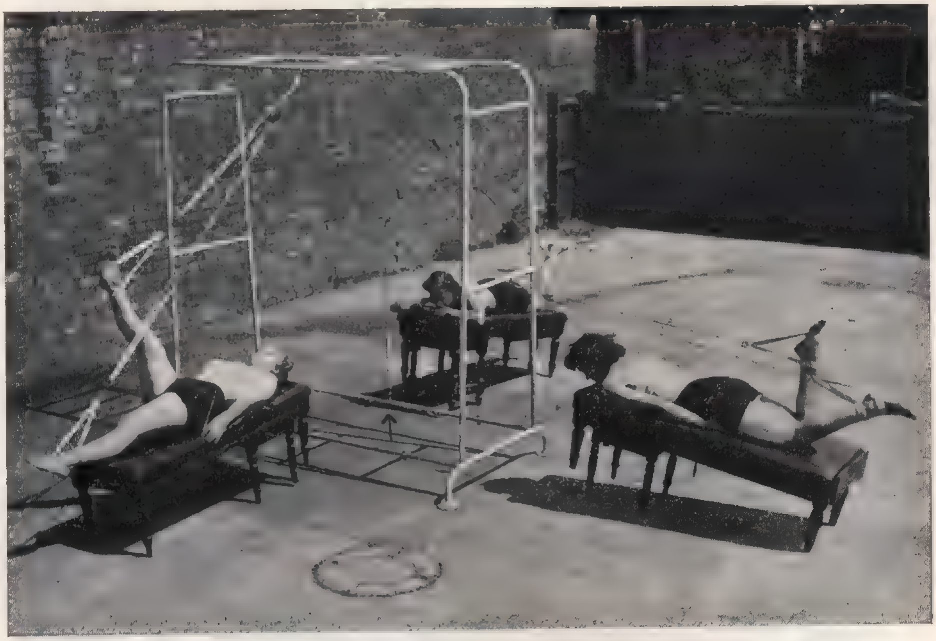
(3) A rhythmic type of movement is obtained.

(4) Exercises are performed by the patient unaided and so secure his co-operation.

(5) By arrangement of the starting position, any angle of pull on a joint can be obtained, to secure special therapeutic effects.

Concerning these exercises it has been stated that :

" Assisted active movements, however, provided the assistance is given by the patient, can do nothing but good. Relaxation of



A B C

FIG. 52.—Group exercise.

Three *different* leg exercises arranged in good starting positions.

Note the three plinths are placed in a sloping position, by inserting a gymnasium stool under the head-end in each case. A tilt on the plinth is necessary ; it allows a full range of movement of the limb, if the feet extend over the edge of the plinth.

the opposing muscles is the crux of the matter, and to obtain this the patient must have perfect confidence. If a second person is providing the assistance the patient instinctively puts the brake on long before the limit of tolerance is reached, because any other

method of informing the operator that he is approaching this point would be too slow to act in time. With the patient himself in control, however, perfect relaxation is possible right up to the full limit."*

Fig. 51 shows a group exercise in the open air. By careful arrangement of starting positions it is possible for one operator to supervise accurately three or more patients while they carry out different exercises.

On the left the demonstrator shows external rotation of the left shoulder, the right arm being used to produce the assisted movement. The centre figure demonstrates extension and slight rotation in elevation. The right-hand figure demonstrates a maximum position for elevation, the muscle-work being isolated by the excellent starting position.

Fig. 52 shows : A, a hamstring-stretching exercise ; B, a muscle development exercise for the quadriceps against the resistance of a strong spring attached to the lower bar of the standard frame (see arrow) ; and C, a mobility exercise for the knee joints.

II. SIMPLE AND STANDARD PULLEY-AND-WEIGHT SYSTEMS

Simple illustrations are given in this chapter which will enable those who have no standard apparatus to build useful substitutes.

Types of Muscle-Work which can be given to a Patient using a Pulley-and-Weight Apparatus (Fig. 53, A to E).

(1) **No work.**—A limb can be counterbalanced against gravity by a weight attached by a rope which passes through a suspended pulley. This weight can then be altered so as to vary the effects of gravity on the limb (Fig. A).

(2) **Static work.**—If the counterbalancing weight is gradually decreased, the patient can still try to maintain the original position, and is able to do so as muscle power improves (Fig. A). This involves static action.

* A. E. Nicoll, F.R.C.S., in *B.M.J.*, April 5, 1941.

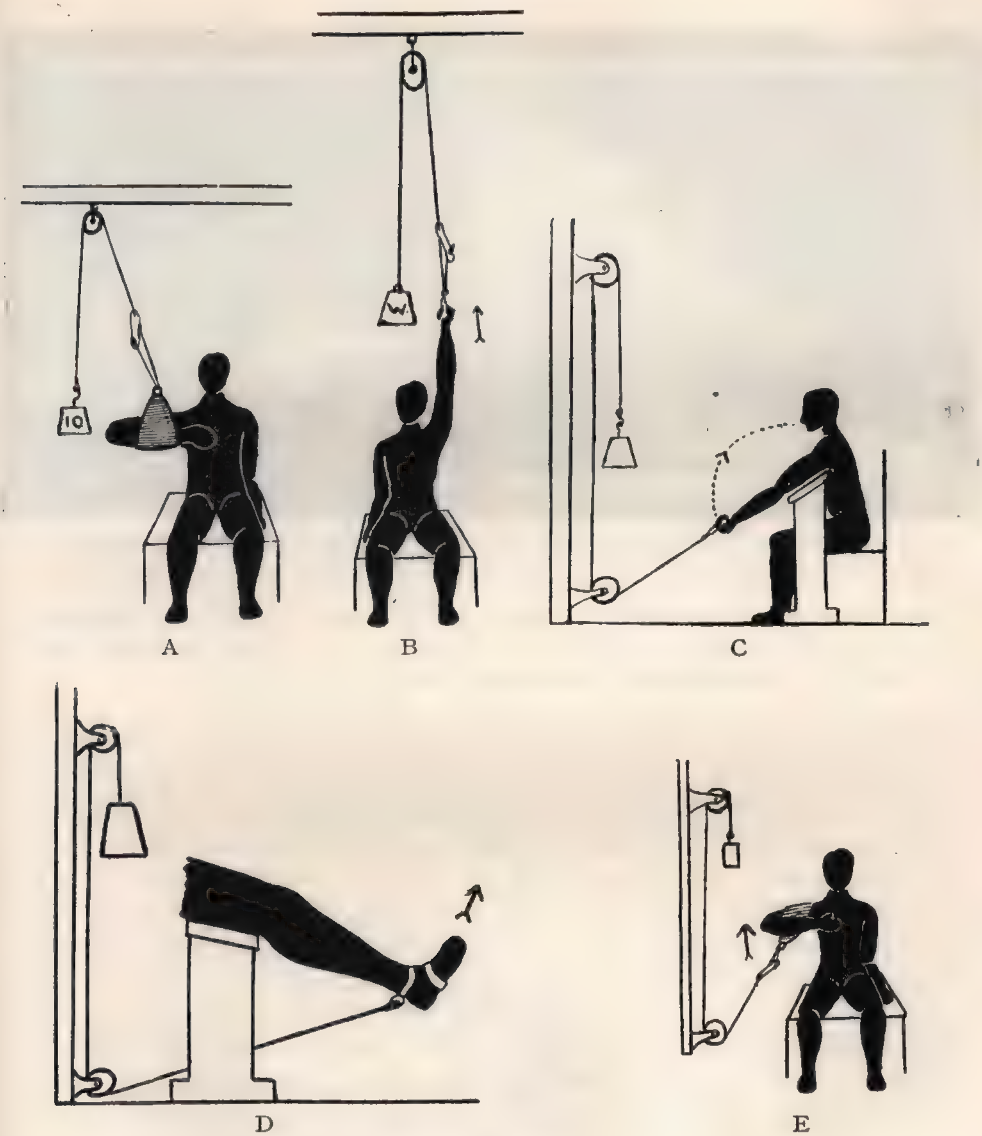


Fig. 53, A to E.

(3) **Eccentric work.**—A pulley-and-weight can be used to give passive traction (Fig. B) and obtain elongation of a muscle or traction to a joint.

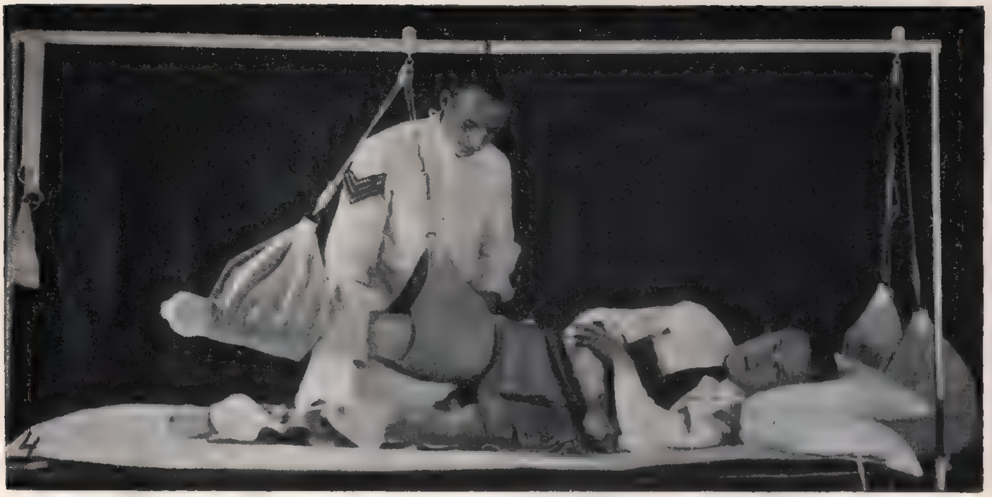


FIG. 54.—The author's combined sling-and-pulley apparatus in use at an R.A.F. hospital.

Ball and socket pulleys slide on the plated bar of this portable sling apparatus. As portability and stability are difficult to incorporate in such light apparatus, it is advisable to tie the uprights to the treatment couch.

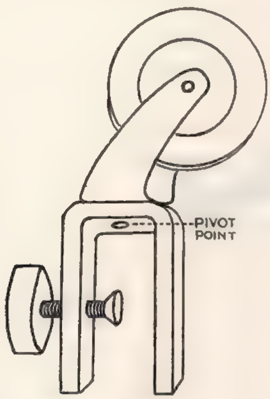


FIG. 55.—Chair pulley, with rotating pivot.

The chair pulley was designed to be of use when visiting cases. It can be screwed to the back of a kitchen chair and is useful for small weight tests and limb treatments. A pad should be inserted between the chair and the screw.

(4) **Concentric work.**—Concentric muscle work against weight and gravity can be arranged in many ways by altering the starting position from sitting to standing positions ; progression of muscle-work can be obtained (Figs. C, D, E) by increasing the weights to be moved.

Gymnastic considerations and rules.—Strict gymnastic positions must be insisted upon while the exercises are in progress. It is most important to isolate muscle-work. For instance, supports to the knee joint and for the elbow are illustrated and are essential for correct movement.

The work to be undertaken must be thought out carefully with regard to the muscle-work required. A high or low pulley selected, graded weights arranged and placed ready to hand, and a good starting position thought out before the patient can proceed with the exercise.

If possible the patient should *watch* the movement of the weight, and although the work is self-activated it should be closely supervised.

PULLEY-AND-WEIGHT THERAPY

A pulley-and-weight is used in remedial gymnastics for several purposes :

(1) To gain a method of self-activated exercise which has the definite advantage of being used to promote muscle development. Graded weights are used which are of known values ; *i.e.* $\frac{1}{2}$ lb. to 20 lb., etc. These are constantly adjusted in strength to suit the condition of the patient. As joint and muscle work together, the joint will be moved and its function improved.

(2) To gain a method of assessing voluntary movement by checking up on the strength of the injured side, against the strength of the sound side taken as a " standard." (Berry Hill Hall Rehabilitation Centre method.)

Muscle Development

With regard to remedial exercise with pulleys and weights, Dr. J. B. Mennell has fully covered the subject in his book " Physical Treatment " (4th Edition), with instructions and illustrations. In addition he has made the following most useful comment on the value of

Stanley Cox & Co.

THE "TRANSPORTABLE" SUSPENSION UNIT

FIG. 56.—The Apparatus set up for use.

FIG. 57.—The Apparatus folded.

This is a new design of full suspension apparatus. It is rigid when erected over a bed, yet it can be dismantled and packed into a canvas case in three minutes. The frame-work consists of a double tubular bar extending lengthways and ending in wide legs which grip the head and foot of the bedstead. To secure extra rigidity, a rope is slung under the bed and fastened to two hooks on the frame-work, and tightened by a wooden cleat. The sides of the bed are thus free from apparatus, and the operator has uninterrupted access to the patient.

such movements: "There is somewhere in human nature a desire to see the results of work performed; and especially with the uneducated, there is a sense of satisfaction in seeing a weight ascend, in response to a pull on a cord which passes over a pulley. So much is this the case that a patient who is content to spend twenty minutes in the performance of this exercise will frequently refuse to spend five if requested to use a roller-towel instead!

"Also, it is more simple to teach patients to graduate their exercises if using apparatus, and there is, in the use of apparatus, the spirit of opposition that incites to accomplishment, which is absent in feats entailing perhaps greater skill and effort, where no apparatus is used. The more simple the apparatus the better will be the result."

Some Notes on The Berry Hill Hall Rehabilitation Centre Method for Muscle Development

By JOHN COLSON, M.C.S.P., Berry Hill Hall.

"The remedial exercises that are used at the Berry Hill Hall Rehabilitation Centre for strengthening weak muscles do not consist of Dr. Arvedson's classical remedial exercises, nor of the 'class' exercises of the average hospital department, for few of these exercises are strong enough to strengthen muscles to the degree required for heavy work. The exercises mostly consist of specially designed weight-and-pulley exercises, which can be adapted to any muscle group, and of educational gymnastics modified for remedial use.

"The apparatus for pulley-therapy has been designed to treat up to thirty patients at a time, and will allow them to exercise with weights up to 200 lb. In addition it incorporates the various pulley-and-rope circuits used for assisted active mobility exercises advocated by Mrs. Guthrie Smith.

"The pulley circuits are suspended from movable swivels running in various steel trackways, fixed to the gymnasium ceiling. In this way all the pulley kit can be swept to one side when the gymnasium is required for free remedial exercise work, or physical training, and brought out again as required.

"With this system it is possible to have all the pulley apparatus required, but at the same time to keep the gymnasium neat and tidy. This is very important, for nothing looks worse and detracts from an appearance of efficiency than all the pulley-exercise gear hanging untidily from the ceiling or looped up to the walls.

" There is a special arm trackway, holding the types of circuits used for arm and shoulder cases ; a quadriceps trackway, housing the circuits required for exercising these muscles ; an ankle trackway, holding the circuits for exercising the ankle and its accessory joints ; and a spinal trackway, containing the strong circuits needed for use with spinal cases.

" About the exercise technique used here : We now lift the maximum exercise weight 10 times *instead of* 15 to 20, as before. This is lifted continuously without a rest-pause after every fifth pull. But after every contraction of the working muscles they must have an adequate period of relaxation and rest.

" A word of warning should be given about this method of exercising weak muscles. *It should not be used in cases of very weak muscles,* for the maximum exercise weights used are too much, and may do damage. Minimum weights should be used only in these cases, starting off at two or three minutes and progressing by adding a minute a day to the time, and a half a pound or quarter of a pound to the weight, whenever the patient feels he can do this.

" We now have a basic rule, to avoid any danger of overdoing things, in assessing the degree of the strength and type of the exercise which should be used for the particular condition. The most common mistake is to use too great a weight for both minimum and maximum exercise, and to excessively foster the competitive spirit among the men doing this form of exercise. Soldiers, especially, enter into the spirit of competition, and endeavour to see who can lift the greatest amount ten times. In this way a great deal of harm can be caused.

" Only recently an orthopædic surgeon of note told me that he knew definitely that faulty pulley-and-weight technique had been responsible for increasing the incapacity period of some of his cartilage cases by two weeks.

" I should think that this is quite common. The use of the weight-and-pulley is very valuable in remedial work, but unless those who teach the technique are experienced, and have sound remedial knowledge to guide them, the exercises will not give the beneficial effects which are claimed for them, and it is possible to produce harmful effects.

" Fig. 58 shows how to rig up pulleys and weights to provide graduated but strong resistance to the extensor muscles of spine and hip. This method is used to obtain maximum muscle de-

Fig. 58.—Group exercise at Berry Hill Hall.

Strong resisted exercise for extensors of spine and hip.

velopment after spinal injuries, and represents a practical method of handling a number of patients.

" Fig. 59 shows a method of using pulleys for muscle development for the quadriceps. The sandbags which are used for

resistance are all of measured graded weights which are gradually up-graded as the patient's vigour demands."

FIG. 59.—Group exercise.

Muscle development for the quadriceps.

These illustrations have been lent by John Colson, M.C.S.P.

(2) Method of Testing Muscle Strength*

At Berry Hill Hall this method consists of *testing the voluntary movement of the injured limb against the standard set up by the sound limb.* This test gives an evaluation of muscle-strength in pound weights lifted, and is carried out to a maximum, if necessary.

It is obvious that muscle power may be assessed by expressing the power of a particular group of muscles as a fraction of the sound side. In the case of the extensor muscles of the back, which cannot be expressed in this way, a known standard is determined by testing normal subjects. The apparatus necessary to determine muscle efficiency is a system of pulleys and weights designed so that any desired movement can be isolated and performed against measured resistances. In the quadriceps extensor group, for example, the method employed is to load the sound leg till its "exercise tolerance" is reached. By this is meant the greatest weight that can be raised fifteen to twenty times in succession as an exercise. The same procedure is then repeated on the injured leg, and the result expressed as a fraction, *e.g.* $\frac{R}{L}=\frac{12}{25}$.

These muscle-efficiency tests have been carried out in a great many conditions, and the results are very instructive. For example, in compression fractures of the spine treated by reduction and ambulatory plaster for four to six months the efficiency of the extensors of the back is often as low as 20 per cent. after removing the plaster. This is so in patients who have done exercises throughout the period of immobilization. The results of these muscle efficiency tests are charted week by week in the form of a graph, and constitute a very reliable guide to progress and to the value of different methods of treatment.

(1) On admission the *sound* limb of the patient is tested, the limb and joint are carefully isolated and the muscle-strength assessed against graded resistances supplied by pulley-and-weight apparatus.

* Extracted by the author from writings by A. E. Nicoll, F.R.C.S. and John Colson, M.C.S.P.

The *greatest* weight that can be lifted 15 *to* 20 *times* in succession is the required standard for that limb, and the weight is carefully recorded.

(2) The *injured* limb is now tested against *this standard.* The "maximum exercise weight" having been discovered, the injured limb is tested against it; the result is expressed as a fraction sum:

$$\frac{\text{Right}}{\text{Left}} = \frac{\text{10 lb.—injured leg.}}{\text{26 lb.—good leg.}}$$

These results are then plotted on a graph.

(3) The next process is to determine what is the *greatest dead weight* that can be lifted *once only* with the injured limb; then with the sound limb. The result of this test is expressed as another fraction sum; this is called the "maximum effort—tolerance weight."

Example:

$$\frac{\text{Right}}{\text{Left}} = \frac{\text{15 lb.}}{\text{35 lb.}}$$

Exercise technique is then based on this information:

(1) The weight is halved that was lifted 20 times (*i.e.* $7\frac{1}{2}$ lb.). This is called the "minimum exercise weight." This weight is then used on the first day's treatment for three minutes continual exercise with weight-and-pulley gear.

(2) Rest period of a minute or two follows.

(3) The maximum exercise weight is then lifted 20 times, with a minute's rest after every fifth pull.

(4) A further rest and the minimum weight is again used for three minutes' exercise.

Daily increase of effort is advocated by increasing the time factor by *one* minute; the weights are also increased by minute doses; *i.e.* $+\frac{1}{4}$ lb. to $\frac{1}{2}$ lb. daily increase.

OTHER RECORDS AND TESTS OF VOLUNTARY MOVEMENT

Every Physiotherapist has from time to time to make reports to the doctor about a patient's progress. Nothing is more annoying than to have to report in vague terms. If a record of treatment

is kept, and from this a schedule of progress compiled, it will be much more satisfactory for all concerned.

It is important to try to evaluate voluntary movement by testing out group-actions of muscles. Much valuable information can be gained which can be studied in conjunction with the usual electrical tests of individual muscles.

The standard tests of voluntary movement used in most hospitals are based on Lovatt's grading system; this classifies muscle strength mainly in its relation to *gravity*. With this system there are six grades—arranged in numbers one to six, each number has a corresponding and appropriate symbol, as follows:

Strength of contraction

Gradings.

(1) N = Normal contraction.
(2) R += Contraction against gravity and resistance.
(3) R −= Contraction against gravity only.
(4) G −= Contraction with gravity eliminated.
(5) F = Flicker.
(6) O = No contraction.

Within the limit of these six gradings a report can be made, but for *two classes* of patients, it does not help us.

In the first class a patient may be able to contract his muscles against gravity and resistance; but his injured limb may be much weaker than the sound one. With the tests advocated by Mr. Nicoll a further useful record can now be made up to a maximum fitness.

In the second class the patient may be so weak that to obtain any information gravity must first be "eliminated." For such patients some help in recording may be obtained by tests of voluntary movement carried out with the limb in suspension (as described in Chapter V).

The limb about to be tested is supported so that gravity and friction are balanced out, and the supports which hold up the limb must be pivoted from a point *exactly* over the axis of movement, *i.e.* the joint about to be moved.

It is realized that all tests have only a relative value and are not scientifically accurate; but they are useful as:

(1) A guide to treatment;

(2) A record of treatment ;

(3) They appeal to and offer encouragement to the patient.

To make the scheme clear, the matter is set out in the following manner :

Heavy weight-and-pulley method

↑

Tests of muscle efficiency.

(No. 1, 2, amplified.) ↑

Comparisons between the injured limb and the sound limb as " standard."

Strength of contraction (Standard symbols)

(1) N = Normal contraction.
(2) R + = Contraction against gravity and resistance
(3) R − = Contraction against gravity only.
(4) G − = Contraction with gravity eliminated.
(5) F = Flicker.
(6) O = No contraction.

Further tests for paresis Nos. 4, 5, 6 amplified, as shown in the following table.

↓

Patient recumbent ; limb supported in axial suspension.

(1) Oscillatory test.

(2) Distance test.

(3) Halt test.

(4) Pulley and small graded weights as tests (Fig. 61).

FIG. 60.—Tests for paresis.

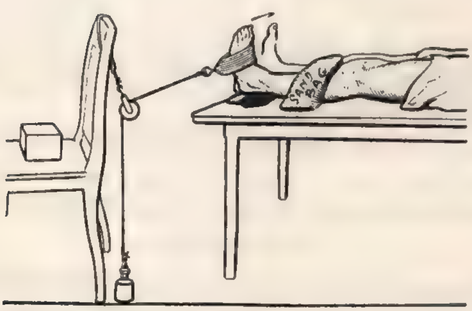


FIG. 61.—Graded weight and chair-pulley used to test the strength of the anterior tibial group of muscles.

Chapter X

SPRING THERAPY

The Use of Helical Springs for Assistance and Resistance in Remedial Treatment

Assistance to voluntary movement is called for, and is often necessary when a muscle group is enfeebled or damaged and unable to perform its normal function. Such a muscle group must not be strained or worked beyond its strength, but should be assisted in the earliest stages of its recovery.

Assisted movements are of various types ; the most usual are carried out *manually* by the operator. This manual form of treatment is the most sensitive and adaptable, for there is no machine so sensitive as the human hand, and in no other way can such fine gradations of movement be carried out. But when manual assistance is not necessary it may be a waste of valuable time ; patients can make use of other means of assistance with benefit to themselves, and they should be encouraged to do so.

Water baths are convenient and useful adjuncts to treatment, and should be available whenever possible. If the water is warm, much comfort and relaxation is obtained by exercise in this medium, especially for the treatment of foot and hand injuries.

The value of deep pool therapy is now well understood, gravity is eliminated, and natural movement in all the limbs is encouraged.

Sling-suspension for weightless exercise has certain advantages in regard to assisted movement ; these can here be summed up briefly as follows :

(1) *One muscle group* can be isolated and controlled for re-education by minimal exercise on a horizontal plane. The opponents are thereby relaxed and stretched by reciprocal action.

(2) A very *wide range of movement* is obtainable in most of the larger *joints*, as the patient is encouraged by easy rhythmic movement to make a maximum effort.

(3) Relaxation and comfort are promoted especially if a large heat lamp is placed over the patient.

Polished surface.—A sheet of polished mill-board is also used to assist weak muscles to function. By its use friction is largely eliminated and the force of gravity is controlled. This is a specially convenient method of assisting hand and foot movements, and allows for careful observation and control. This technique was elaborated by Sir Colin McKenzie in 1916 and is well known to all physiotherapists.

Graduated faradic contractions are of real assistance when voluntary power is difficult to bring into action. *One* muscle group is brought into action by stimulating its motor nerve, but the antagonist is also affected ; in other words reciprocal innervation occurs, and the antagonist is relaxed.

Two new types of assistance are now suggested which will be found useful for various conditions. These have been named :

I. Oscillatory ;
II. Rhythmic recoil.

SPRING ASSISTANCE

I. OSCILLATORY EXERCISES

An oscillatory system of exercise introduces a new type of movement which is full of possibilities for obtaining early self-activated work ; suitable for *the Aged ; Joint Stiffness* and *Paresis.*

By taking advantage of the oscillatory, or vibratory property, of a long helical spring, we can design exercises which have many applications in therapy.

A suitable spring must be selected and attached by one end to an overhead point and by the other to a sling. The limb under treatment is then comfortably suspended in a position of equilibrium. The vibratory motions which occurred when a free weight was hung on a spring, as described in Chapter III, are now somewhat altered ; for in the case of the human body we are no longer dealing with a dead weight but with a living limb which is attached to a joint. The oscillations are influenced by either the physiotherapist or the patient, who can now stop the movement, augment it, or keep " in resonance " * with the movement of the spring.

* See Chapter III.

There are certain types of *Joint Injuries* or joint conditions when only movement of the gentlest description is required. The smallest oscillatory motion has the effect of relaxing muscles and loosening joints. The starting positions assists a patient to "shake loose" a stiff joint by gentle movement. This type of exercise offers a welcome variety of treatment to both patient and operator, and has been used with success for selected cases, where there was no underlying septic condition.

This method is also useful when there are only very low reserves of muscular strength and energy available in an *Aged Patient*. The desired movement is made by the patient himself and can be maintained with very little effort if the motion of the spring and the movement of the patient are in resonance with each other.

Paresis.—Patients unconsciously react to the friendly assistance of the spring-buoyancy, and as their muscular strength increases, the movements gather speed and momentum. Muscular development can thus be gradually encouraged and built up till a true resisted movement results, the apparatus is then adjusted to the new requirements. These self-activated exercises are capable of much gentle repetition and should be used bilaterally whenever possible. The springs in oscillation will allow exercise to be performed in *all planes* and axis of movement, and in this way muscular development and joint mobility will progress at the same time.

A patient can, by means of small muscular contractions repeatedly applied, maintain of his own accord, as large or as small a range of movement as his condition may allow. Any small application of effort at the appropriate time will be cumulative in effect. Patients are thus enabled to move their stiff joints and to obtain some control over them. In fact, the necessity for forcible manipulations has been prevented in certain cases.

Fig. 62 shows how the weight of the limbs can be balanced out by spring suspension, and the power of the extensors of the hip is used to perform small but rapid ranges of movement.

The diagram illustrates how to set up this oscillatory exercise to encourage hip-joint movement. Both legs are strapped together

so as to form a single unit. This exercise has proved of value for the treatment of selected cases of osteo-arthritis.

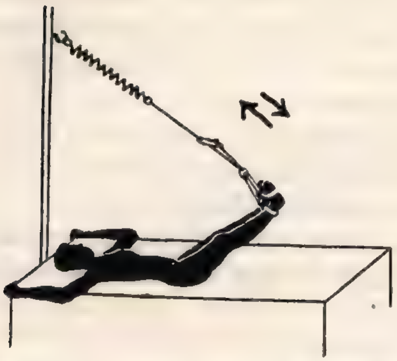


FIG. 62.—To mobilize the hip joint and restore tone to the gluteal muscles.

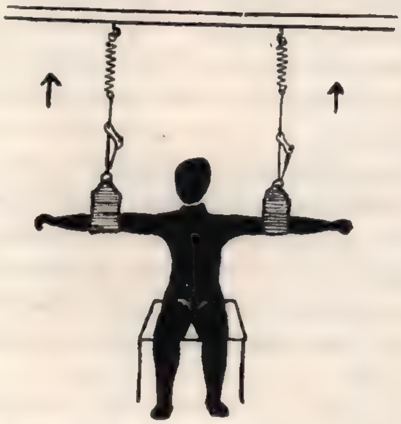


FIG. 63.—"Assisted" muscle-work for the deltoid by system of springs.

A further diagram (Fig. 63) illustrates how to use this method of exercise, for the region of the shoulder joint. This exercise can fulfil two purposes: (1) It can be used to assist a weak deltoid in its movements against the force of gravity; (2) it can be used to obtain movement in the humero-scapula joint. In the latter case the support should be moved as close to the wrist as possible in order to obtain more leverage

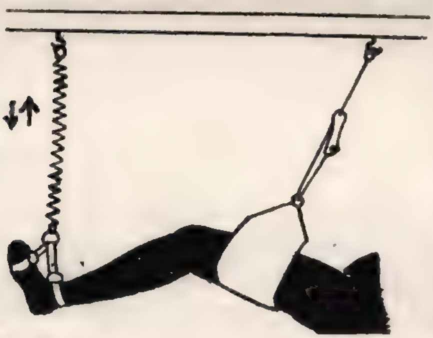


FIG. 64.—To mobilize the knee joint.

Fig. 64 shows an arrangement which will allow a small range of oscillatory movement in the knee joint. (A light spring should be used which allows the lower leg to be balanced at about half the range of the spring.) This is a useful movement to employ for the treatment of poliomyelitis, as it encourages muscle activity in the region of the knee-joint. In all these exercises during the rest period, the limbs are held at a point of equilibrium by the accumu-

lated energy stored in the spiral spring. These mobility exercises are completely under the control of the patient.

Fig. 65 illustrates how to set up a modification of the oscillatory exercise. This is easily arranged if overhead bars are available. A belt is slipped under the lumbar spine, and a spring is attached to either side. The patient's body is lifted by the ropes, so that he is raised slightly off the bed. The patient's movement is now helped by the recoil of the spring as he lifts his lumbar region *against gravity*; he breathes in during the upward movement; then presses down against the spring (assisted by gravity) and breathes out as the downward movement takes place. Thus the rhythm of movement assists respiration.

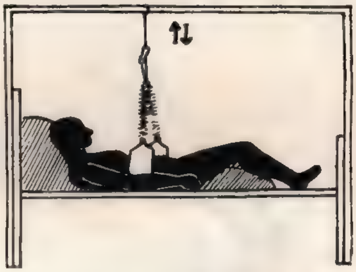


FIG. 65.—A lumbar mobility exercise; *but* when given with *breathing* a double overhead bar should be used, and the springs and ropes separated by at least 18 in. or 2 ft., so that the chest is not compressed in any way.

Such an exercise has many advantages:

(1) Respiration is deepened and *stasis in the bases of the lungs will be prevented.*

(2) The spinal muscles are exercised, the lumbar region mobilized, while the hips and shoulders remain quiescent. For those who have suffered an arthrodesis of the hip joint this arrangement will be found very helpful.

(3) The normal lumbar curve is maintained.

One practical advantage of this arrangement is that the belt can be slackened off by the rope, so that the patient can have the apparatus left in position ready for further exercise when desired, throughout the day.

(Fig. 66.) An easy exercise for the abdominal muscles. The patient's body-weight is taken by the two springs as shown in the starting position of kneeling. The head is supported on the folded arms and hands. The flexors of the hip are put out of action by the knee-sitting posture of the starting position. The abdominal muscles are assisted by gravity, when small flexion movements are

made (indicated by arrows), the abdominal muscles work in the inner ranges of flexion and rotation. If the forward movement is combined with breathing out, a further retraction of the abdominal muscles will be possible.

This arrangement of abdominal work has been satisfactorily employed for the treatment of paresis of the abdominal muscles: alternatively, sitting with legs over the end of the plinth and leaning the body-weight on the spring supports will probably be found a more suitable starting position.

FIG. 66.—Abdominal work assisted by gravity.

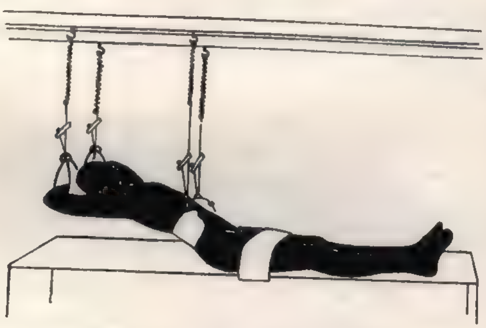


FIG. 67.—Easy back work.

(Fig. 67.) The body-weight is balanced on four suitable springs, the patient sets up small movements with his extensor and lateral back muscles. The spine can be rounded so that the vertebral column is mobilized ; or it can be held so that the hip joints only are moved. This is an easy exercise for a patient with poliomyelitis.

Progression.—A partly-assisted and partly-resisted exercise. An intermediate development can be made between the oscillatory and resistance exercises, if the patient works up some range of motion, whether large or small, and at a signal attempts to " stop " or check the movement of the limb or body. The aim will now be more directly *muscle development*, as opposed to mere mobility,

or muscle re-education ; thus a partly-assisted and partly-resisted exercise will result.

Fig. 68 shows the starting position for such an exercise ; the two legs are strapped together. The arrows indicate a method of using the hip extensors, first, by small vibratory movements counting 1, 2, 3 ; then, by holding the limb down on the plinth *against* the resistance of the spring ; and finally, by relaxing slowly against the upward traction of the spring until the starting position is regained.

In the first part of the exercise, advantage is taken of the kinetic energy of the spring-recoil to work up movement from weak to strong ; the remainder of the exercise is concentric and eccentric muscle-work of the hip-joint extensors.

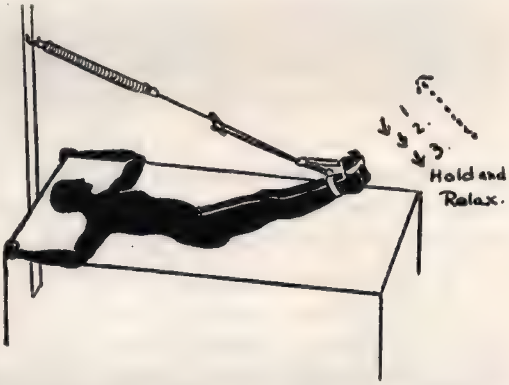


FIG. 68.—Oscillation and resistance combined.

Between the exercises the knees are flexed, and remain balanced by the apparatus in a rest position.

This exercise can be carried out in the wards, or is just as suitable for the gymnasium ; as also for group treatments, for it is easily supervised and not liable to error.

The resistance can be increased by grouping springs in parallel, or by carrying out the exercises in quick or slow time, or by employing both means.

The author is convinced that the oscillatory exercises, if they are carried out with good will, may be found to be of great value for the treatment of *Chronic Cripples*. These patients should be *given a chance to move themselves ;* and by movement to restore some well-being and function to their bodies. This matter is further discussed in the chapter on the " Rehabilitation of the Warded Patient " (p. 242).

II. A RHYTHMICAL-RECOIL-SYSTEM TO EXERCISE ATONIC MUSCLE BY "ASSISTED" MOVEMENT

A second new method of muscle stimulation is suggested, because it will assist the patient to initiate impulses which have been lost, and to regain *the knack of* contracting his muscles.

Using the recoil action of a helical spring, a muscle is assisted so that it can lift a limb against gravity; as a *natural movement of the joint* is obtained at the same time, a true functional movement is simulated.

It must be clearly understood that the patient must play his part, concentrate his thoughts, and attempt to contract his muscles at the same moment that he is being assisted; otherwise the movement will be passive. This *thought-process is most important: where the thought is, there will the muscle-work be;* if any effective contraction is available it will only function in this way (Fig. 62).

Many muscles must always work against gravity. Such a necessity arises when a patient has to lie supine for long periods. In these circumstances remedial treatment is limited to tensing exercises, static contractions or the application of graduated faradic current. Both these methods can be applied singly, or, better still, combined together, and both can be incorporated with this new assisted exercise.

The principles of the method are as follows:

(1) To balance out adverse leverage by spring suspension.
(2) To cause a reflex stimulation through the stretch-reflex mechanism and obtain a natural movement of the joint.

Indications for treatment.—This method of treatment has been found of value when treating certain surgical conditions, such as leg injuries which have been confined in plaster; and when recovery of full extension of the knee joint is the primary aim of treatment; and for cases of disuse atrophy. It has been found that the atonic muscles receive a stimulus which reawakens muscle-consciousness, and the reflexes of the joint are stimulated into action by repeated movements. These combined actions aim at a straightening and strengthening of the knee joint.

Rhythmic recoil.—The operator is responsible for and controls the rhythm and recoil of the movements by controlling the stretch and recoil of the spring system. First the muscle under treatment is put on the stretch, while the spring is put on tension. Secondly, when the tension is released the muscle will be assisted in its movements against the force of gravity and against the disadvantage of its adverse leverage.

The patient must also play his part, and learn *to time* his muscle contractions to take place at the correct moment. For this his thoughts must be concentrated on his actions, and his eye must be kept on the movements of the spring.

Adverse leverage and how to overcome it.—Nearly all the muscles of the human body work in the third order of leverage. They are capable of very rapid action in moving their bony levers, as they are inserted as close as possible to a joint (or fulcrum). The point of insertion is the point of power, or that point where the force of the muscle is exerted. The distance between this insertion and the joint is the power arm; and from the joint, the length of the bone carrying the hand or foot is the weight arm. In this third order of leverage, the weight arm is often six to eight times as long as the power arm. This results in a mechanical disadvantage for the muscle (Fig. 69).

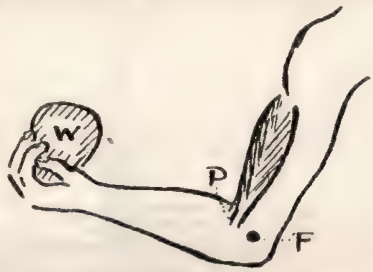


FIG. 69.—Third order of lever.

If the insertion of biceps is one-sixth of the distance between the elbow joint and the palm of the hand, the muscle must exert a 6-lb. pull to move a 1-lb. mass in the hand (disregarding the weight of the forearm itself). A small movement of the biceps tendon will produce a large movement at the end of the lever, and gives a very large range of movement to the hand, *i.e.* when the muscle contracts it lifts its point of insertion 1 in., but the hand will be lifted 6 in., as it is six times as far from the fulcrum as the muscle insertion. If muscle-tone is normal, movement will be normal; but if muscle-tone is lost, or the muscle damaged, the mechanical disadvantages will be too much for it, and therefore no movement at all may occur. Such a condition is often met with in the quadriceps

muscle : the weight-arm of the muscle is very long and wasting of the muscle-tissue only too common an occurrence.

(Fig. 70.) The smaller inset diagram shows the order of leverage of the quadriceps. The larger diagram illustrates how the adverse leverage can be balanced out with spring suspension, so that the lower limb is held in a position of equilibrium, and at such an angle that an effective movement can take place in the direction of extension. It will be noted that action occurs only in the quadriceps. The ham-string group of muscles are eliminated from all activity, owing to the fact that it is *the operator who depresses the patient's limb.*

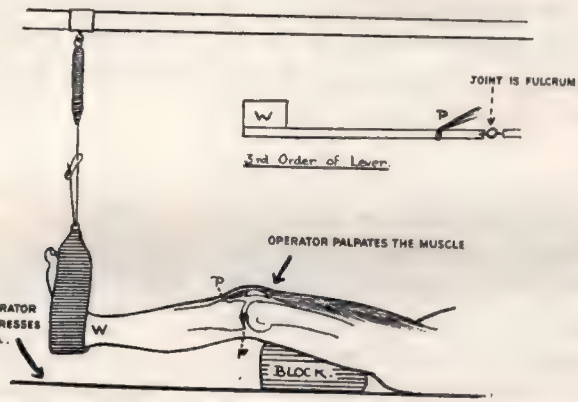


FIG. 70.—How to balance out adverse leverage. The *inset* diagram shows the leverage of the quadriceps.

Muscle stimulation through the reflexes.—It is understood that in a case of disuse atrophy both sides of the reflex arc are intact. To obtain normal movement the whole reflex element in the spinal cord must work, but it may well be that " in consequence of injury to the knee joint, muscle wasting is rapid and progressive, the muscle decreases in bulk and in some cases no flicker of movement can be obtained. The *reflexes to the joint appear to be blocked,* an almost total inhibition may be observed, the muscle might well be paralysed, it is so powerless." *

This state of affairs calls for immediate treatment. The inhibition must be overcome as soon as possible so that wasting

* *Fractures and other Joint Injuries.* Watson-Jones.

shall cease and the power of contraction be restored. Therefore, in the treatment now suggested a reflex stimulation is arrived at, by setting up a series of repetition movements involving :

(*a*) Muscle stretching before contraction ;
(*b*) Repeated stimuli by contact of joint surfaces.

These aims are based upon matter which is well expressed by the quotations now given, from Best and Taylor.

The stretch reflex.—" The reflex contraction of a healthy muscle which results from a pull upon its tendon is called the stretch or myostatic reflex. . . . If 0·8 per cent. of the original length of a muscle is stretched it will elicit a response. Stretching, whether slow or rapid, evokes a response. The force of muscular contraction is automatically adjusted to the degree of stretching applied. . . . The stretch reflex is obtained predominantly from the muscles which maintain the upright posture." Also quoting from Bowen and McKenzie, " We can, by guiding new movements through *numerous repetitions*, set up a habit cycle which will tend to unblock, and force a passage through the synapse paths which have not been working."

Technique and apparatus (Fig. 71).—(1) With one hand the physiotherapist presses down and puts the spring on tension ; this action sets up a slight stretch-reflex in the quadriceps.

(2) With the other hand the quadriceps is palpated so that the operator is ready to feel and detect the coming contraction.

(3) As the operator relaxes the pressure on the spring, the spring will recoil and the lower leg will be lifted and extended against the force of gravity ; the knee joint is moved in a natural way.

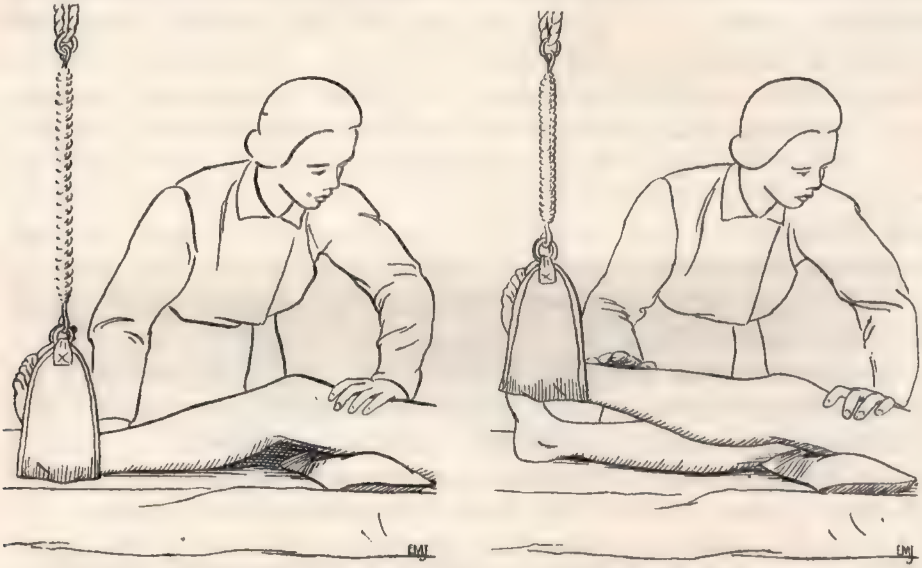
(4) The patient on his side must co-operate ; he is told to watch the spring, to note its stretch and recoil, and is encouraged *to contract his quadriceps in time with the rhythmic recoil.* In this way the knack of contracting a muscle is mastered ; the action need not be passive or mechanical.

To sum up, once the rhythm of the treatment is under way the following results are obtained : A stretch is produced in the muscle ; this is followed by the recoil of the spring, a contact of the joint surfaces, and a voluntary muscle contraction. Thus a good physiological sequence is set up, of stretch-and-contraction.

Finally graduated faradic stimulus can be superimposed if the patient is unable to make the contraction without further aid.

To " assist " muscle action.—When a spring is put on tension and then relaxed it will exert a force sufficient to lift a given weight against the force of gravity. It is very important to select a spring which is not too strong, or the recoil action will be too fast and too vigorous.

The selected spring should be stretched to one-third to one-half of its length when the lower limb is in the position as indicated in



(*a*) Muscle stretch. (*b*) Recoil and contraction.

FIG. 71.—Rhythmic recoil in action.

the drawings ; then the recoil action will be of moderate strength and the pace will be of such a rate that it can be easily observed by the patient and imitated. It must be clearly understood that the patient must be attentive, and watch the spring recoil, learning to contract his muscles at the appropriate moment, *i.e.* on the recoil of the spring. If there is any effective contractile function available in the muscle, this repeated muscle-training will be of benefit in stimulating function.

The apparatus required will be an overhead bar, an adjustable

rope, a narrow belt to support the foot, and a suitable helical spring to balance the lower leg. To start the exercise, the spring should be on the stretch. The foot is suspended by the rope and spring, and attached to a sling under the os calcis ; the rope must be carefully adjusted to obtain the proper point of balance. A block support, or one or two books up to 4 in. in height, should be placed under the lower end of the femur to isolate the joint, and to give sufficient space to exercise the quadriceps in its inner range of movement.

If it is found that the rhythmic-recoil apparatus (as illustrated) does not give the desired effect, and the movement of the spring is too rapid, then the spring should be changed to one that is weaker ; alternatively and more easily *more weight* in the form of small sandbags can be added to the patient's limb till the " perfect " balance for treatment is found. This would make for accurate work and prevent the worry of having to find an exact tension spring suitable for the treatment.

Patients vary so much in their disabilities that it is impossible to lay down the law and quote the exact suitable outfit to use, but if the lower leg is assumed to weigh about 10 lb. a spring of 30 lb. could be tried out.

A further indication for treatment.—It is sometimes found that the antagonists to enfeebled muscles become so hypertonic that it is impossible for the prime-movers to work against their resistance. This condition is not infrequently observed, for example, in the hamstrings which become hypertonic to weakened quadriceps. These cases require a definite technique ; the aim of treatment is then to obtain relaxation of the antagonist muscles through *reciprocal inhibition.*

For these cases the use of rhythmic recoil and voluntary movement with, or without graduated faradic current is necessary, as by these means, and with careful technique, treatment is isolated, so that *only* the quadriceps are stimulated ; the hamstrings are not treated, except *by reciprocal-inhibition,* which will cause a relaxation not obtainable in any other way.

Stimulation and inhibition.—" Nerve impulses cause muscle contraction, but they also cause a muscle not to act, or to be inhibited. Less tone is then set up than is found in the normal

resting state." (*Applied Anatomy and Kinesiology*, Bowen and McKenzie.)

SPRING RESISTANCE

"EUTONIC" RESISTANCE EXERCISES

(Gk.: Eu—*good*; tonic—*tone*)

I. General and Local Exercises

"Eutonic resistance exercise" is a name given to a series of original spring-resistance exercises designed for patients who are confined to bed with fractures, or other areas of immobilization. These patients are often quite strong enough to do active movements with their sound limbs to keep themselves fit; their activity has a profound influence on the circulation, and checks the tendency to clotting of blood, which is a frequent sequel of trauma and inactivity in convalescence.

The name *Eutonic* was given to these exercises by a surgeon who practised them daily while recovering from a serious fracture of his femur. He not only suggested the name but did much constructive work with the author in thinking out these exercises.

His misfortune was her good fortune because this patient was not only a well-known surgeon, but a brilliant anatomist, and one keen on physical culture. As each movement was worked out, it was given an anatomical basis; above all, as a doctor he could feel for himself the movements that were favourable or unfavourable to his fractured limb, as well as appreciating the value of generalized exercise for his health.

It is a well-known fact that *muscles work best when they work against resistance.* The art of working up muscle development is therefore undoubtedly one of understanding how gently to progress such exercises that there will always be further demands upon the muscle under treatment. At the same time unnatural muscle development of a single area is quite wrong and the whole body requires attention. Used scientifically and with common sense rehabilitation exercises, such as are indicated in this chapter, can be

brought to bear upon that often neglected sphere, the "general condition" of the patient, as well as to the actual injured part.

Manual resistance, and treatment by massage, is usually given by the physiotherapist to the uninjured leg as well as to the other limb, or the patient himself may perform "free" exercises, and learn to tense his muscles. The method now suggested is for the physiotherapist to make use of resistance apparatus, which can easily be fixed, adjusted and graded. By this means many more varied and interesting exercises can be carried out, and, above all, the patient will be the unaided performer!

A ward full of patients can be treated at one time; but the method requires *personal supervision,* as the exercises are selected individually for each case, and graded to suit the patient's strength. This is found to have a more favourable psychological effect than massed physical exercises, by "class work."

The exercises aim at the restoration of muscle tone and the prevention of wasting and weakness; so that when the patient is able to get up, he can walk without that weakness which is so commonly experienced after a long stay in bed.

In selected cases, the springs can be left with the patient, so that he may practise the exercises by himself, thus a proportion of his time will be spent each day in a personal effort to get well.

The spring-resistance exercises are divided into generalized exercises and special local exercises for the injured area; these latter are described in the following chapter, and classed according to the region of the body to which they are applied.

II. The Minimum Apparatus for Eutonic Exercises

A fixation point (The Lifting Pole and Chain, a standard hospital fixture, can be utilized, if sufficiently high).
An adjustable rope and sling (see page 36).
A high-grade resistance spring (helical type: 30-, 40- or 50-lb. springs can be used).

Exercises for the arm.—Fig. 72 shows the starting position for a strong active exercise of the extensor muscles of the shoulder.

Fig. 73 shows the spring "on tension." The extensor muscles are required for raising the body in bed, and also for walking with crutches; it is therefore important to strengthen these muscles. For weak patients a short lever can be used by flexing the elbow and grasping the top of the sling with the hand.

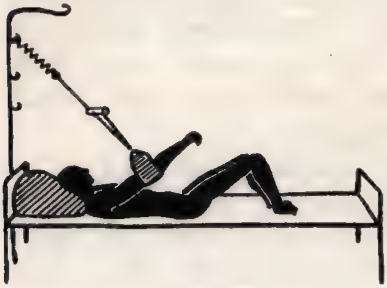


FIG. 72.

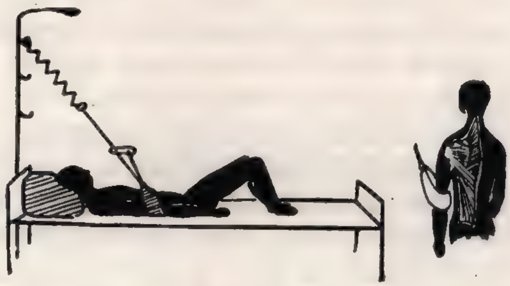


FIG. 73.

Eutonic exercises. (Musclework.)

The starting position for an exercise for the pronators and supinators is shown in Fig. 74. The handle is grasped and the spring is put on tension by extending the shoulder joint. This position is maintained statically, while active pronation and supination movements are made. The hand must grip the handles firmly.

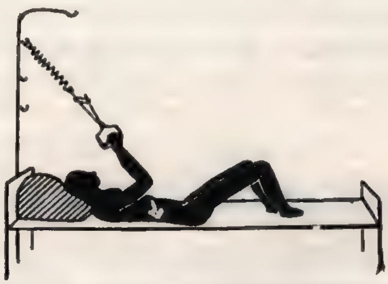


FIG. 74.—Pronation and supination.

Exercises for head and neck.—Long convalescence in bed induces elongation of the muscles of the neck and upper dorsal region, and unless tone is re-established bad habits are easily acquired, which will ruin good posture. The following exercise is designed to correct this tendency.

(Fig. 75.) The head is placed within the sling, with the chin raised, it is then pressed back against the resistance of the spring. This will work the short intrinsic muscles of the head and neck on the atlanto-occipital joint. As a variation, if the chin is "held in" the upper dorsal muscles which are attached to the head will function. By keeping the spring on tension, side flexion and rotation movements of the head can also be carried out.

Exercises for the lower limb.—Foot exercises. The thigh and leg are raised, so that they are at right angles to each other, and to the bed. The fore-part of the foot is supported by the sling. This rather insecure position makes the foot muscles work to grip their support; the spring must be put on tension. Much static muscle-work will therefore take place in the whole leg before

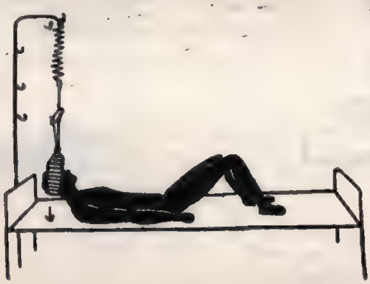


FIG. 75.—Head work.

the actual plantar flexion, dorsi flexion, inversion, and eversion are carried out in this position.

These exercises are designed to keep tone in the calf and foot muscles, and to prevent flattening of the arches.

Fig. 76 shows the starting position with a new arrangement of the rope and sling. The patient now holds the rope by a loop handle, and he must manipulate the rope in such a way that he can vary the length of the circuit and adjust the resistance of the spring by altering the length and direction of the thrust.

Circumduction of hip.—Circumduction of the hip joint with the spring on tension can be carried out, in as perfect a circle as possible, with slight manual control on the rope loop. This movement will influence the circulation of the great vessels crossing the hip joint, as well as mobilizing the joint.

Hip extension.—With hip and knee kept at right angles as before, the heel is dipped until it touches the bed and returns under control. For this exercise it is best to support the whole foot in the sling, and to concentrate on contracting the glutei.

Hip and knee extension (Fig. 77).—A strong thrusting action is made with all the muscles of the leg, extensors and side-flexors of the trunk. The patient must pay attention, concentrate all the time, and control the return movement, otherwise the spring will recoil and much of the value of the exercise will be lost. This thrusting exercise is of great importance and will stimulate all the leg muscles, revive sensory impulses in the sole of the foot, and bring into play the primitive "thrust reflex."

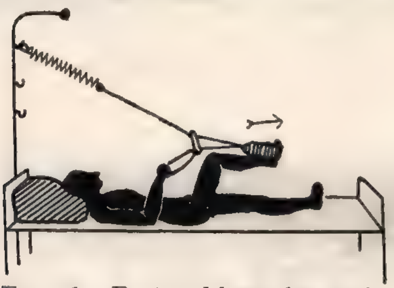


FIG. 76.—Foot and lower leg work while spring is kept on tension.

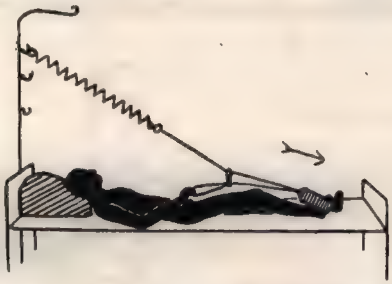


FIG. 77.—Thrusting and controlled return.

"Free" exercises performed in the recumbent position are fatiguing, owing to the continuous lifting of a limb against gravity, and they tend to become dull and uninteresting, whereas spring exercises can be repeated far more frequently, with less fatigue, and with a definite feeling of exhilaration due to the momentum and speed of the vibrant spring.

The spring, however, must be strong enough to suspend the limb in equilibrium when the coil is slightly elongated; also strong enough to offer adequate resistance to muscle-work; and finally, its recoil must be sufficient to bring the limb back to the starting position.

To prevent straining the spring, adjustments should be made with the rope, so that all types of exercises at any joint can be accommodated without moving the patient; but the spring should be put well on tension for satisfactory exercise.

Under the guidance of the physiotherapist, patients can carry out many and diverse schemes of exercises. In this way their interest and co-operation will be enlisted.

With only a *single* fixation point, above and behind the patient, the exercises must necessarily be limited largely to thrusting movements such as those illustrated. However, these movements are some of the most valuable for toning up the anti-gravity muscles of the legs and back. The muscle-work is *concentric* when the spring is elongated and *eccentric* when the recoil of the spring is controlled by the patient. There is much *static* work if the spring is held " on tension " as a starting position for some of the exercises. The limb is *at rest* when held in equilibrium by the tension of the spring.

If additional fixation points can be arranged, such as are available in the standard suspension apparatus, endless variations in exercises can be performed—including resistance work involving more than one limb at a time. Such activity is shown in the exercises which follow in chapters XI and XII.

See also Appendix 1—The " Bed Gym."

CHAPTER XI

REHABILITATION IN THE DEPARTMENT

The exercises given in this chapter, which can be incorporated into any existing remedial scheme of exercises, are of several types involving four basic general effects and uses :

A. *Relaxation.* B. *Rhythm.* C. *Activity.* D. *Group work.*

The general effects of such exercises will be to obtain :

(A) Relaxation in comfortable support. This will precede the active periods of treatment if suspension methods are used.
(B) All movements are rhythmic by virtue of pendulum, pulley, or vibratory systems.
(C) All the exercises are active, and many are resisted ; all elicit to the full the co-operation of the patient.
(D) Group treatments can be composed, and easily supervised, for re-education of movement or rehabilitation purposes.

SPRING-AND-PULLEY SYSTEMS CONTRASTED

In this chapter it will be shown how much value can be derived from the use of springs for remedial gymnastics ; but the use of a pulley-and-weight system can be of equal service. It has been shown that force opposed by a stretched spring varies with the extension ; thus, a spring is *not* suitable where an exercise or a *test* calls for resistance of fixed value. In such a case use should be made of the equally simple mechanism of the weight-and-pulley, a castor-type or swivelling-pulley being employed whenever possible to ensure that the cord lies within the groove from whatever direction the pull is taken ; graded weights should be used.

The two mechanisms, spring and weight-and-pulley, are *not* altogether interchangeable. There is no property in the weight-and-pulley system corresponding with that which we have called the "vibratory" or "oscillatory" property inherent in a long spiral spring. Also from the point of view of *treatment* there is a marked difference between the values of spring or pulling resistances.

(1) *When a spring is used* (in connection with an adjustable rope circuit as in the Eutonic Unit) the movements made by the patient are of small range and the muscles therefore work chiefly in the *inner ranges* of their contraction. Consequently, the capsular and ligamentous joint structures *are never overstretched and muscle training is begun in the safest way.* Also the angle-of-pull can be adjusted as found necessary and the spring itself is never used to its fullest capacity. The spring will extend with increasing resistance to the force applied to extend it. Springs offer variable resistance: the output of force cannot be accurately measured.

(2) Movements made against a pulley-and-weight resistance require from half to full ranges of movement. The weight lifted is a known fixed value quantity, so the work carried out can be accurately assessed and we obtain a *valuable test* of progress.

Many of the standard pulley-and-weight apparatus require proper fixations of a more or less permanent character, and are therefore more suitable for the gymnasium than for work requiring constant alteration of position, such as is found to be necessary in the treatment of warded patients. It is for this reason that the spring units offer greater advantages of ease of fixation, portability and liveliness in work.

Both pulley and spring systems adapt themselves equally to *group* arrangements for treatment; in this way a team spirit is inculcated to which patients react well.

Both systems offer self-activated, rhythmic, repetition exercises of great value *if correctly supervised* and scientifically applied *with due regard to anatomical and pathological considerations.*

REGIONAL EXERCISES FOR TRUNK AND LIMBS

I. REGION OF THE BACK

Exercise for Various Muscles of the Back

Effort and Rest.—The principle of effort and rest in eutonic exercise is well demonstrated by the two illustrations which show this put into practice.

FIG. 78.—Effort.

The demonstrator is shown in action, carrying out strong extensor muscle-work of head, neck and upper back muscles over the fixed point of the central sling belt, against the resistance of the springs but assisted by gravity.

FIG. 79.—Rest.

Here the demonstrator is shown relaxed and supported on spring-suspension. The head rests on the folded hands and arms.

Periods of rest and work follow each other in alternate rhythm, and the exercises can be kept up for quite long periods.

The spring resistance can be graded so as to suit individual patients ; but the springs must be strong enough to suspend the body during the rest period in a position of relaxed comfort. The exercise shown is quite a strenuous one, involving nearly all the back muscles; the demonstrator is young, strong and supple. Strong springs are necessary in this case so that adequate resistance can be given ; but for other subjects much lighter springs could be used.

As a variation the lateral side flexor muscles can be put into action without extension, an easy side-swinging taking place ; or as an additional exercise, with muscle-work combining extension and lateral flexion.

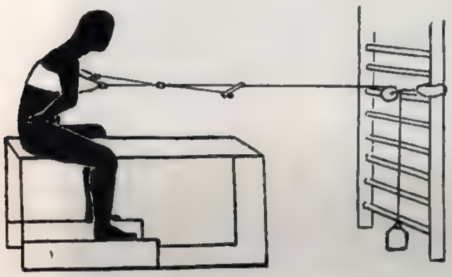


FIG. 80.—A general strengthening exercise for the hip extensors and the muscles of the back. The knees should be strapped to the plinth.

Alternatively, an exercise using only small muscle contractions would involve the small intrinsic muscles of the back rather than the longitudinal group ; it is most important that the intrinsic muscles should be strengthened ; small extension movements with unilateral rotations will achieve this object, and can be performed by the patient in this apparatus against the fixed point which is given by the dorsal belt. These movements can be kept up for a considerable time, as the rest intervals are so easily arranged.

(Fig. 80.) A useful general exercise for the hip extensors and the muscles of the back, the resistance being supplied by a pulley-and-graded weight.

TO WORK THE MUSCLES OF THE LOWER BACK

Lumbar mobility (Fig. 81).—An exercise designed to work the lower spinal group of muscles, and to gain mobility in the lumbar region. The legs should remain in the crook position throughout the exercise and be strapped together at foot and knee to form one

unit. This will exclude the hip joints from much movement ; the rapid alternating movements should take place in the lumbar spine. A very strong and *long* spring is necessary for the exercise,* as it must not only balance the weight of the two legs at a point of equilibrium, but it must still be able to offer adequate resistance to the powerful lower back muscles. The abdominal muscles and quadratus also come into play as the sacrum is lifted from the couch (as in Fig. 81). In the next figure (Fig. 82) activity is much increased by the simple expedient of tilting the couch about six inches at the upper end.

FIG. 81.

FIG. 82.

For lumbar mobility.

Quoting from Sir Colin MacKenzie's *Action of Muscles :*

" Should the dorsal and cervical spines be fixed, as when, for example, an acrobat lies on his back, contraction of the quadratus lumborum results in flexion of the sacrum, pelvis, and so of the lower limbs at the lumbar joints. Contraction of the erector spinæ, when the acrobat is lying prone, will similarly produce extension at these joints. Thus the quadratus is an important factor in maintaining spinal equilibrium."

This quotation is rather apt, as the figure in the diagram is like an " acrobat " and shows the muscle-work clearly. The inclusion of the spring-resistance, however, brings emphasis on to the spinal muscle-work, but does not altogether exclude abdominal and

* Or this can be built up with a series and parallel arrangement of four springs (see p. 36).

quadratus action. Much depends on the pace of the action and the volition of the individual performing the exercise.

To Work the Muscles of the Upper Back and Neck

Head suspension can be arranged as in Fig. 83. In this case we have the advantage of self-activated movement which is carried

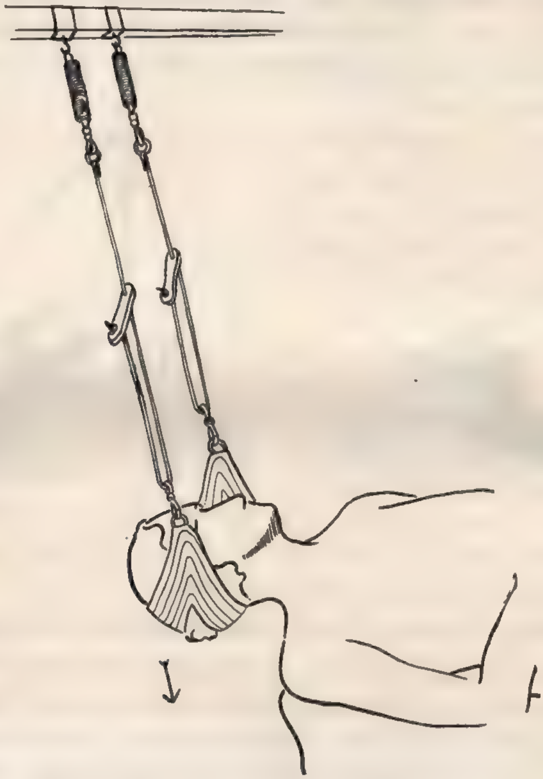


Fig. 83.—Head suspension and resistance.

out against the resistance of suitable springs of moderate tension This arrangement of resistance is most usefully employed when treating such conditions as spondylitis deformans and severe kyphosis, as the muscles of the upper dorsal region are activated as low as the sixth dorsal vertebra as well as the muscles of the neck.

Longitudinal traction can also be given by the physiotherapist

who then sits behind the patient and supports the head lightly between the hands and applies the traction.

This same position is convenient for localized massage to the neck muscles, as perfect relaxation can be obtained with this arrangement of sling suspension. For massage the fingers are pressed upwards against the spine and occiput.

Resistance Exercises isolating some Important Muscles

The Rhomboids

FIG. 84.—Encouraging muscle-work in the region of the scapula against spring resistance.

(Figs. 84 and 85.) **A resistance exercise** is shown which will increase scapula movement and strengthen the rhomboid muscles. The patient lies on one side, the arm being abducted and the forearm flexed to a right angle with the arm. The forearm is suspended by a broad sling which is attached to a rope and light spring from an overhead point. A rope held in the hand is attached or held from below if the patient is working alone. The rhomboid muscles are made to contract so that the

scapula is pulled towards the spine against the resistance of the spring ; the muscle is relaxed and contracted repeatedly.

The rhomboids act chiefly on the lower angle of the scapula adducting it, and so rotate the scapula downwards and backward. If these muscles are paralysed the angle of the scapula projects conspicuously from the back.

The rhomboid muscles are very important muscles for the working man and they will repay careful investigation after an

FIG. 85.—The rhomboids isolated for exercise.

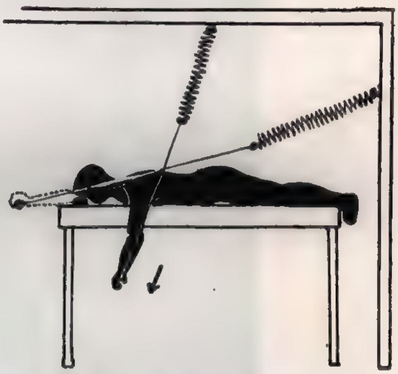


FIG. 86.—Serratus anterior in action as prime mover in thrusting downward, and as a synergist to the trapezias in elevation of the arm.

arm injury, because on them depend such actions as a sailor has to perform in rowing a boat, hauling on a rope, or a carpenter when he uses axe or hammer. Therefore, a special exercise to isolate their action, such as Fig. 85, may be found to be of particular service in getting a patient back to his pre-accident state.

(Fig. 86.) Loss of the serratus is a disabling injury, as it interferes seriously with the forward movements of the shoulder. Lack of the serratus will prevent the arm from being lifted higher than the shoulder, and the vertebral border of the scapula will

project backwards in an unsightly manner. All arm movements are adversely affected without a proper fixation of the scapula by this muscle.

(Fig. 87.) The latissimus has been referred to previously as the "corset of the spine." This important muscle can best be localized by giving bilateral movements of extension, adduction and inward rotation at one and the same time. This can be carried out against the resistance of a suitable pair of springs.

FIG. 87.—The latissimus dorsi in threefold action.

The exercise is progressed by altering the starting position to a more forward stooping posture than is shown in the diagram, or is still stronger if taken in kneel-sitting.

Paresis of this muscle results in forward displacement of the shoulder. This is due to the unbalanced pull of the pectoral muscles. The latissimus dorsi also acts in raising the trunk when it is inclined slightly forward, bringing it up to the erect position. Excessive use in this muscle in back-straightening may produce lordosis, therefore this exercise is indicated for "flat" back conditions.

Special Note : FOR NERVE INJURIES.—For cases of nerve injury, when one muscle is weaker than another, it is well to use *springs of unequal strength.*

Thus the weak side and the "good" side can be exercised together in bilateral movement. This is an advantage not to be gained otherwise than by the use of graded springs.

II. REGION OF THE ABDOMEN

THE ABDOMINAL WALL

When considering the abdominal wall and devising exercises which will restore tone, it is as well to consider all the functions with which this group is concerned.

"The abdominal wall is involved in *two* important reflexes, that of posture and breathing." These facts open our eyes to all the

larger issues at stake if abdominal tone should be lost. The physiotherapist will have to consider the appropriate breathing exercises that should be given. These will, of course, be expiratory exercises, as the abdominal muscles are the antagonists of the diaphragm, and the diaphragm must not be allowed to over-distend the abdominal wall by unopposed action if it can be avoided. With regard to posture, balanced action is necessary on both sides of the trunk; abdominal and back exercises must be co-ordinated so that the symmetry of correct posture is not disturbed.

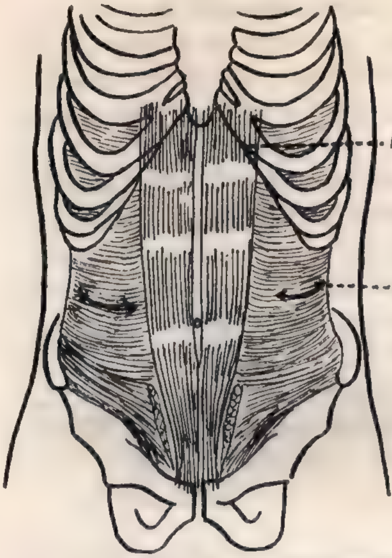
Visceral support is cared for by the interlacing of all the abdominal muscles, which are arranged like a strong basket, with upright, transverse, and oblique stays, all braced together by fascial support. Sir Colin MacKenzie says that the *curved surface* of the abdomen is of such an excellent mechanical pattern that it will sustain both perpendicular and lateral resistances at the same time. The well-knit muscles by their co-ordinated actions are able to support the viscera in proper position, and at an adequate intra-abdominal pressure. The abdominal wall also assists the viscera in all expulsive acts, reinforcing the impulses arising from the organs.

For re-education and rehabilitation, muscles should be exercised in all their group actions:

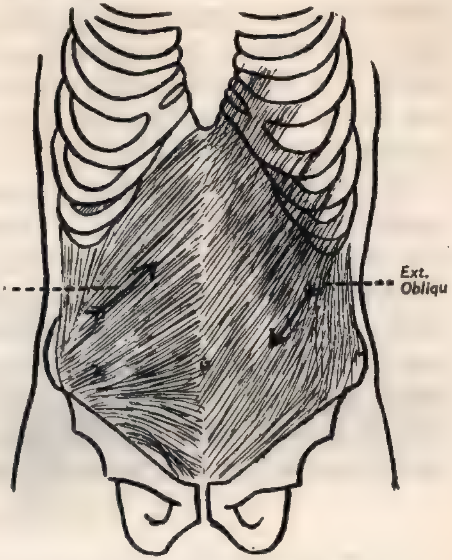
(1) Prime action.
(2) Antagonist action.
(3) Synergic action.
(4) Fixative action.

Anatomical exercises.—We can strengthen the abdominal wall in three ways. The first might be called *anatomical*, that is to say, following out *each set of fibres* in each muscle, as illustrated in the diagrams (Fig. 88, *a*, *b*, and *c*), and giving exercise in the primary movements of flexion, side flexion and rotation, so that each muscle is exercised to the full in all its ranges, and as far as possible unilaterally; then both sides together, with free and resisted exercises.

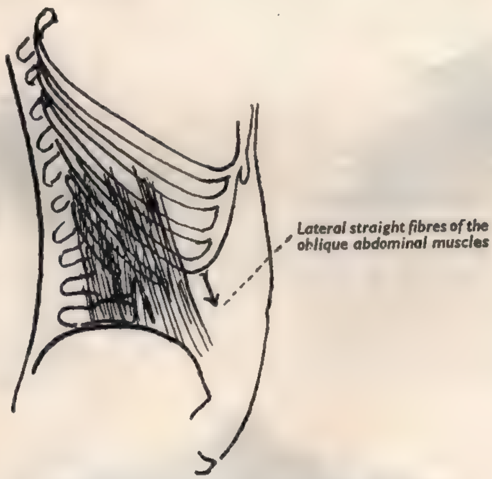
Secondly, by using the *synergic actions* of the muscles, such as are necessary for the performance of abdominal retractions, or pelvic tilting.



a. The straight and transverse muscles: flexor and supporting functions.



b. Oblique fibres: rotators.



c. Lateral straight fibres: side flexors.

FIG. 88.—The abdominal wall.

Thirdly, making use of *the natural fixative actions* which occur when other parts of the body are engaged in strong actions. For example, such movements as throwing a ball a long way, pushing

a lawn mower against thick grass, are essentially arm movements, but they cannot be carried out without the fixative action of the trunk. "The greater the rigidity of the trunk the more effective will limb action become, and especially that of the upper extremity."

Therefore, our schemes of exercise will include all these ways of using the abdominal wall. Various exercises are suggested which are based on Swedish remedial teaching as to range of movement and progression in strength. Some spring exercises are given which render manual resistance unnecessary, and which can therefore be arranged for group treatments.* Strong, free exercises are found in a later chapter, and the "heavy ball" exercises also described will fulfil the purpose of illustrating a type of natural movement which is stimulated by games. (Chap. XVII.)

* See Figs. 93, 95, and 168.

TYPES OF ABDOMINAL CONTROL

FIG. 89.—A maximum effort of inner range work. If the arms are relaxed and the knee joints extended so that the legs point upwards, further strong abdominal work will occur of a static nature as the legs are lowered.

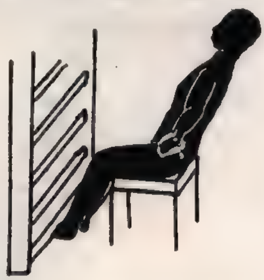


FIG. 90.—Hip flexors in action eccentrically against gravity, with much static abdominal work.

FIG. 91.—To show the outer range of flexion.

Contraction Exercises in Flexion

Fig. 92.—A gentle inner range exercise, usually given with manual resistance.

Fig. 93.—A resisted abdominal exercise. A rod is used with two screw-eyes to which the springs are attached. Two 30-lb. springs would be suitable resistance for most patients. Flexion and rotation can be usefully combined, and carried out in different planes. The patient grasps the rod with forearms pronated.

Fig. 94.—Back stretching and inner range work in flexion in *free* exercise.

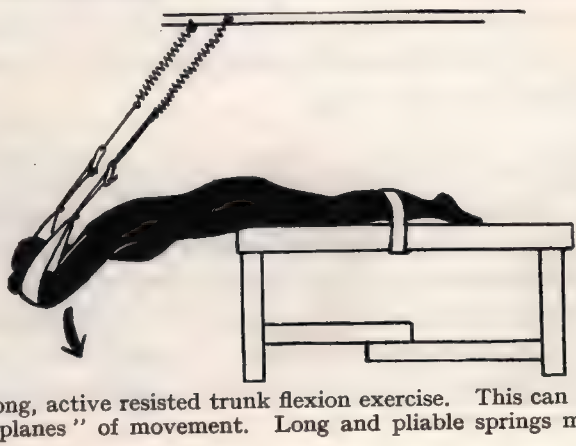


Fig. 95.—A strong, active resisted trunk flexion exercise. This can be progressed to "different planes" of movement. Long and pliable springs must be used for this exercise.

Contraction Exercises in Side Flexion

Fig. 96.—Side flexion, and side flexion and rotation, given free or with manual resistance.

Fig. 97.—A maximum side flexion; trunk and hip abductors working together in the inner range of movement.

Fig. 98.—Stride standing, side flexion, free exercise.

Contraction Exercises in Rotation

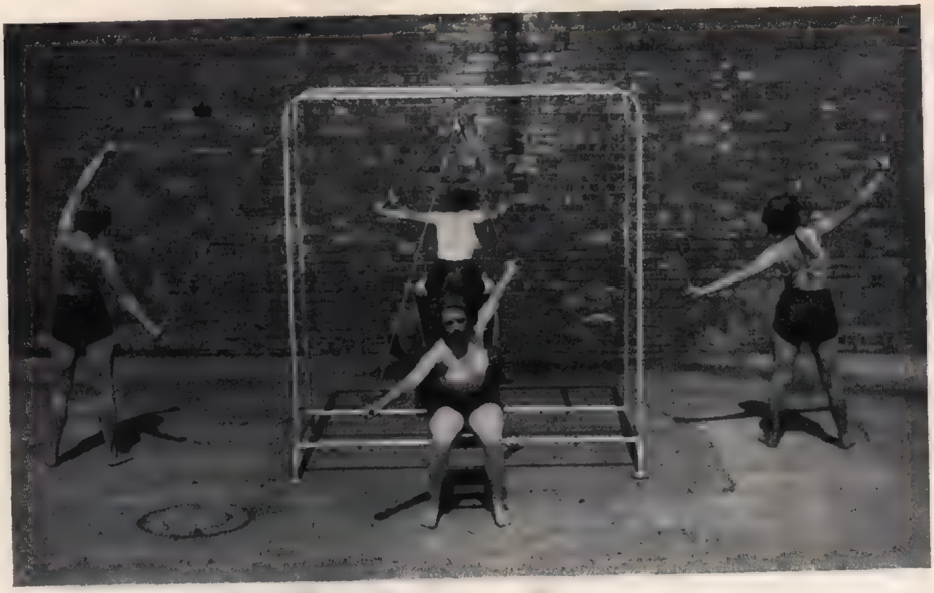
These are carried out with manual resistance or by self-activated movement, using a pole or pulley and rope, or by free exercises, as described in Figs. 99, 229–233.

Trunk Exercises with use of Pulleys

(Fig. 99.) The illustration show clearly how to arrange patients for group exercise. The standard frame is made use of for out-of-door work which makes for health and enjoyment.

Patients enjoy group activity, and it is not always necessary for them to carry out the same exercises. This point is clearly brought out in the illustration. The two central figures perform alternate

trunk rotation in yard-stride-stoop-sitting positions ; the two outer figures are carrying out side-flexion movements, so as to obtain



(1) (2) (3)

Fig. 99.—Group exercise in the open air.

Trunk exercises, side flexion : rotation.

on the left, dorsal action, and on the right, lumbar action in side flexion.

Retraction Exercises

Quoting from Quain's *Anatomy : Splanchnology*, Vol. II, Pt. II, we find this description and diagram (Fig. 100) : " The posterior wall of the abdomen and the pelvic cavity being formed of bones and muscles does not yield to any appreciable extent to increased intra-abdominal pressure ; on the other hand the anterior abdominal wall being much thinner and almost destitute of bony support may be retracted so as nearly to touch the front of the vertebral column or pushed forward so as to be separated from it by a considerable distance."

FIG. 100.—Retraction of the abdominal wall, showing the degree of retraction of the normal abdominal wall.

RETRACTION EXERCISES

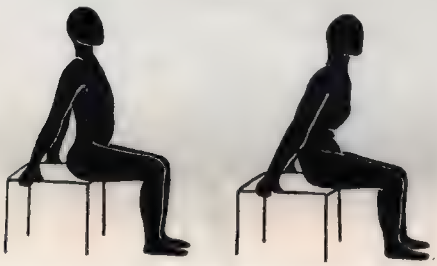


FIG. 101.—Pelvic tilting, with chair support.

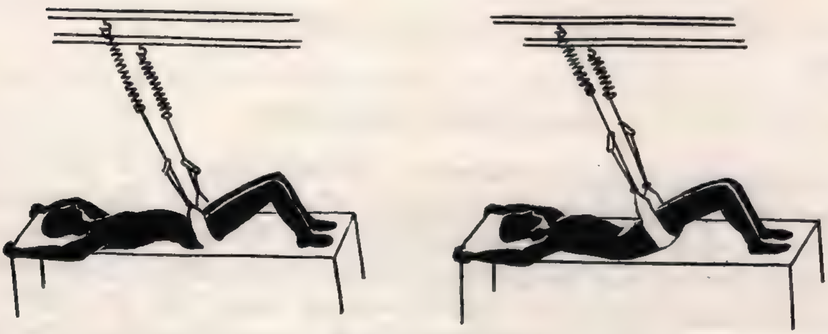


FIG. 102.—A new method of pelvic tilting which offers the advantage of being assisted or resisted, as desired.

With the sling belt under the thighs (as drawn) work is assisted, but, if the belt is placed under the lumbar region, it will be resisted.

III. REGION OF THE SHOULDER

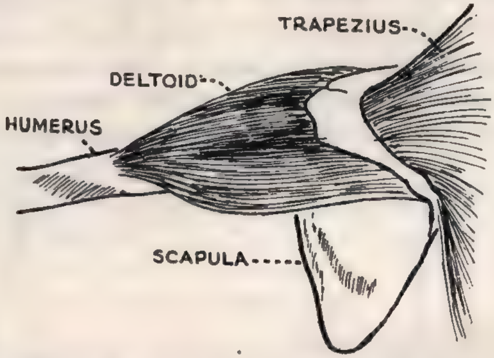


FIG. 103.—The deltoid works as an abductor from about 65° to 90°. The deltoid's coarse fibres quickly waste, and as the weight-arm of its lever is heavy and long, a weakened muscle is unable to abduct the arm against gravity.

The shoulder.—Fig. 104 shows a good position in which to examine and test shoulder movement, or to treat a patient who is suffering from stiffness or injury in the region of the shoulder joint. The arm muscles will tend to relax and be freely movable if they are slung so as to be supported at their centre of gravity* ; for this, the forearms should be supinated, and suspended, from the overhead bar. Movement can then be carried out in its simplest form through one axis and in the horizontal plane.

Alternatively the inclusion of springs of medium tension allows of movement in two planes—horizontal and vertical. The high plinth is chosen, as with it the physiotherapist is able to get on all sides of and close to the patient. When seated behind the patient's head it is possible to detect the slightest discrepancy between the movement of the two arms, and the physiotherapist is conveniently placed for treatments of the shoulder area.

(Fig. 105.) If the surgeon wishes an arm to be placed on an abduction splint so that the deltoid is not stretched nor the humerus adducted, it is quite easy to arrange to carry out movements of the shoulder joint safely in the abducted position in sling supports.

One end of each sling should be placed under the arm and forearm (while the limb is resting on the splint). The two ends should be gathered up so that they can be loosely secured to the suspension

* The centre of gravity of the whole arm is just above the olecranon process.

ropes. The ropes are then tightened until the limb is safely supported. Finally the splint is lowered or removed. Perfect support is thus obtained on what is practically a *movable splint.*

To localize and correct movement the operator should stand behind the patient, support the shoulder, and feel the scapula for incorrect muscle work. Movement should be isolated to the

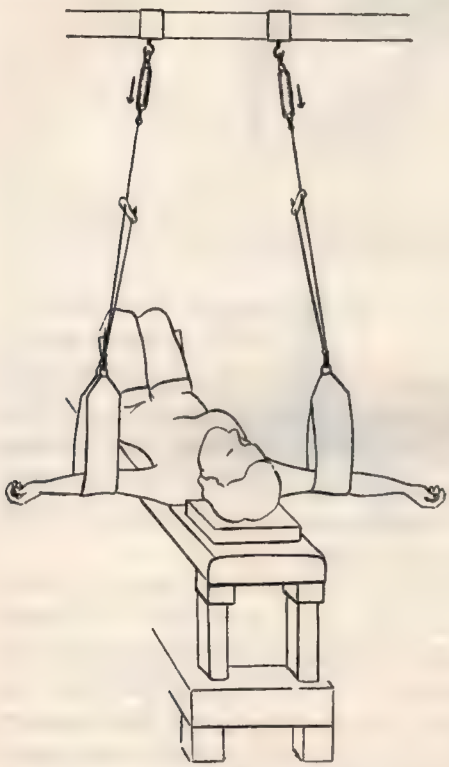


FIG. 104.—Position for preliminary examination of the shoulder movements and for many treatments.

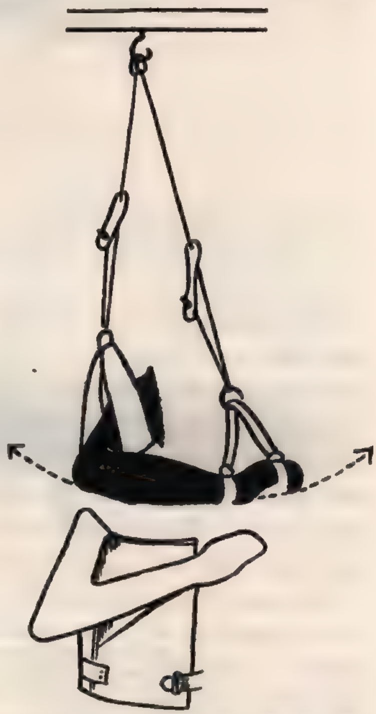


FIG. 105.—Movement in the plane of an abduction splint. The sling should be as wide as possible and carry a gutter splint inside its loop if extra protection is required.

humero-scapula joint, small ranges of movement only being allowed till this is achieved.

(Fig. 106.) For the re-education of a paralysed muscle such as the deltoid, the patient should lie on his back, and the arm be abducted and placed in a wide sling which should support the whole arm. The operator sits at the side of the patient, and at

first assists movement by gently swinging the arm in an upward direction, limiting the movement to perhaps 30 per cent. of the total range. The patient must pick up the rhythm of the swing with his effort to use the deltoid, and he must learn to " time " the effort, so as to synchronize with the up-swing of the movement. The *impulse to abduct* must be strongly emphasized by the operator, who must sit with and instruct the patient until this is achieved. A wider sling should be used than that shown in the illustration.

Fig. 107 shows how to " assist " muscle-work in the neighbourhood of the shoulder joint. Also how to assist mobility in cases where mobility is the chief consideration.

WEIGHTLESS EXERCISE

FIG. 106.— Re-education of shoulder movement by localized Deltoid action.

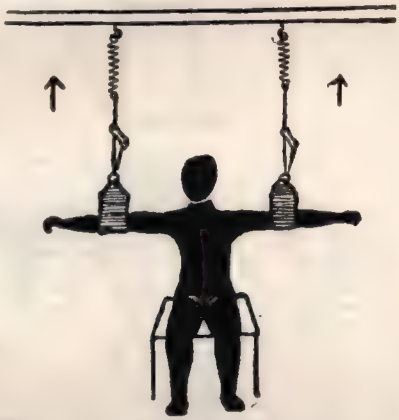


FIG. 107.—Bilateral arrangement for spring-assisted movement of the Deltoid and shoulder joint.

As a start the two arms must be adjusted so that they are balanced against gravity and relaxed. The spring suspension must be of such a strength that the springs are pulled out by the weight of the arm to *half their range*. Movement will therefore occur, both in the direction of gravity and against it, as soon as the patient moves his arms. If the patient (or operator) starts the up-and-down movement with a very slight effort the patient is instructed to take advantage of the kinetic energy displayed by the spring, and " time " his deltoid action to take place with the upward recoil movement. As the movements take place in a very small range, and at speed, it is difficult to be conscious of active muscle-work, but active muscle-work does, in fact, take place (*if conscious*

thought be applied), and it can be observed and palpated by the operator. In this way a weak muscle can be encouraged to function.

This self-activated exercise is capable of much gentle repetition and should be used bilaterally whenever possible. The springs in oscillation will allow exercises to be performed in *all planes* and axis of movement, and in this way muscular development and joint mobility will progress at the same time. This exercise has also been proved of great use for the treatment of chronic arthritic patients.

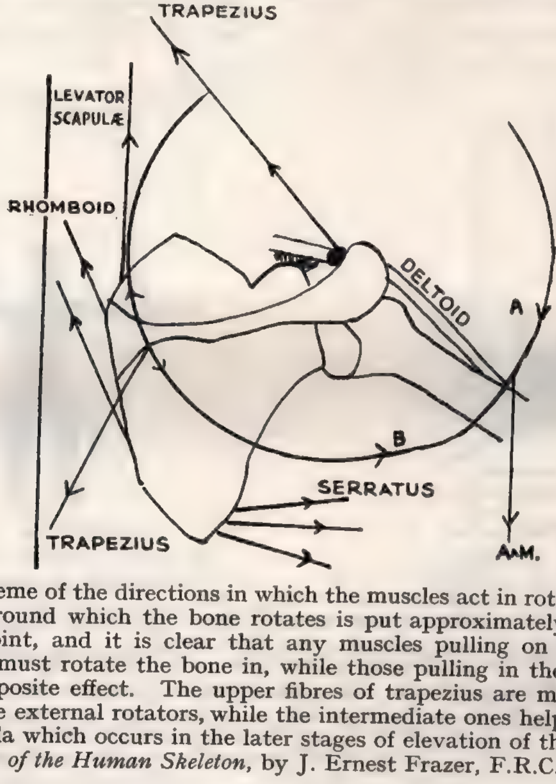


FIG. 108.—" Scheme of the directions in which the muscles act in rotating the scapula. The centre round which the bone rotates is put approximately at the acromio-clavicular joint, and it is clear that any muscles pulling on the circle in the direction A must rotate the bone in, while those pulling in the direction B will have the opposite effect. The upper fibres of trapezius are mainly suspensory, the lower are external rotators, while the intermediate ones help in the retraction of the scapula which occurs in the later stages of elevation of the limb." (From the *Anatomy of the Human Skeleton*, by J. Ernest Frazer, F.R.C.S. (Eng.).)

The shoulder girdle.—When the arm is raised above the head the result of the combined movement of the joints of the shoulder girdle is as follows :

" (1) The scapula is rotated so that the glenoid cavity looks upwards ;

(2) The clavicle is carried backwards and somewhat rotated around its long axis ;

(3) The humerus itself undergoes a rotation so that the lower end is placed in a saggital plane with the lateral epicondyle directed backwards." *

This rotation also brings the bicipital groove of the humerus opposite the acromion process, an important point usually stressed in gymnastics.

Fig. 109 shows how to arrange an auto-assisted abduction movement of the right arm. This is a useful movement for nervous patients, as they learn to move without fear. At first the

FIG. 109.—Auto-assisted movement of shoulder joint.

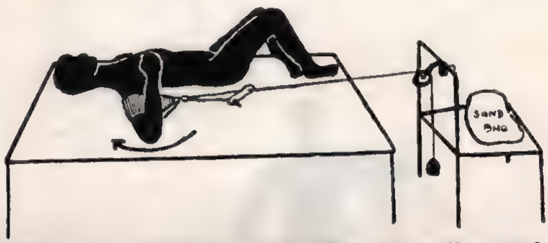


FIG. 110.—Resisted abduction by pulley and weight. The upper arm can also be suspended for this exercise, as in Fig. 106.

movement in an injured arm will be purely passive, but this tendency should be gradually checked, by bringing in "stops" and "holding" movements.

For instance, when both arms are held out at shoulder level static muscle work will take place.

The next progression will be to get the patient *to think* of the one arm only, while the command "push up" is given. The other arm will certainly assist the action, but some slight degree of muscle activity may be awakened in the injured arm. If the patient is left to his own devices this may not be the case, and only passive work will take place, consequently time will be lost.

Fig. 110 represents a recumbent patient re-educating movement

* Quain's *Anatomy*—"Osteology and Arthrology."

in deltoid and shoulder joint against the resistance of a pulley and weight. A short lever is obtained by placing the fingers on the chest wall, and pivoting the movement from this point.

The chair pulley shown in the drawing is a convenient device, as it can be carried about, and fixed to an ordinary kitchen chair.

The chair must be held down in some way (a sandbag is shown). The weights used should be carefully graded, so that the muscle work is gradually increased. The flat re-education table shown in the illustration is 4 ft. wide and covered with linoleum, so that friction to the arm is eliminated as much as possible. It is also used without other apparatus for re-education of movement.

Note.—It is also possible to use this same weight-and-pulley device while the arm is vertically suspended; that position will be more suitable for very weak cases. Figs. 106 and 110 would then be *combined* in this new arrangement.

FIG. 111. Resisted abduction. FIG. 112.

Fig. 111 shows a sharp progression on the foregoing exercises. The patient is sitting and abducting the arm against gravity, and against the *resistance* of a light spring.

The spring is attached to the floor level; a short lever is obtained by pivoting the movement from the fingers which are placed against the chest wall.

Fig. 112 shows a further progression by increasing the leverage of the arm by the stance, which brings into action the whole body. It is sometimes convenient to support the resistance from the patient's foot, if no floor fixation is available.

A mobility exercise.—Fig. 113 shows a position in which the fore-arm acts as a long lever to increase the momentum of the swing. Muscle-work in flexion, and extension of shoulder girdle muscles, represents a large, free movement for mobility. Joints worked

FIG. 113.—Weightless but active arm exercise to increase the range of movement in the shoulder joint.

are the whole shoulder girdle group. The patient's other hand is in low grasp position to steady the body during the swinging of the arm. Note the short spring placed in the rope circuit over the upper rope ; this is to take up any slack which occurs on move-

ment and has merely a " compensating " action on the rope to which it is attached to maintain it at an even tension. A splint can be incorporated within the sling for greater security if the need arises.

(Fig. 114.) The diagram shows how to suspend a case for treatment of the elbow region. The physiotherapist will find that there are numbers of cases calling for similar treatment, because these minimal active exercises are by no means limited to conditions of paralysis and paresis. Cases of recent injury have at their early stages complications calling for equal care and help; and in some cases the need of inducing *active* movement from the first is paramount. Relaxation is also essential, particularly of the opponent muscles. To attain such local relaxation, the joint concerned must be stabilized by the sling supports (employing gutter splints, if necessary), so that the call on the fixator muscles is reduced to a minimum.

FIG. 114.—Weightless exercise for elbow joint muscles.

In the case of painful joints, perfect support, coupled with the patient's confidence in it, and the transfer to the patient himself of the control of the movement, will supply a treatment that is safer, not only from the point of view of the patient, but in every sense; always provided that an active treatment incorporating multiple movement *is ordered* for the case. (For very many conditions multiple movements are absolutely contra-indicated.)

ROTATION MOVEMENTS

Sir Reginald Watson Jones, in *Fractures and Other Bone and Joint Injuries*, states that " if external rotation is completely limited it is a waste of time to practise abduction exercises, or to force abduction by manipulations." Therefore it is obvious that external rotation is a most important movement to restore by all means at our command. Suggestions for obtaining this movement are given in detail.

Actions of the lateral rotators (Fig. 115).—The lateral rotators and fixators of the shoulder joint are only two muscles—the teres minor and the infra spinatus. They outwardly rotate and stabilize the shoulder joint. Their *common actions* are: getting an arm into a coat; dressing the hair; fastening a collar-stud; swinging a golf club. When an arm is injured and supported by a sling the internal rotators are favoured by the position, and there is a corresponding loss to the external rotators; thus these muscles tend to waste and even to atrophy. The physiotherapist should be on the lookout for weakness in these muscles in every case of shoulder injury; in fact they are the first and most important group in which to restore function.

FIG. 115.—The lateral rotators.

FIG. 116.—Standing zero position for rotation movements; can also be done when lying supine.

In Quain's *Anatomy*, edited by T. H. Bryce, "Osteology and Arthrology," it is stated that: "The fullest range of rotation of the humerus—about 90°—is only obtained in conjunction with pronation and supination of the forearm, the elbow being in extension.

(Fig. 116.) A trial on one's own arm will reveal that the humeral head can be felt freely rotating if the arm is allowed to hang by the side. After recent injury, if both internal and external rotation movements can be carried out throughout the day, and at the earliest opportunity after the injury, much will have been done to prevent the formation of periarticular adhesions.

Lying (Fig. 117).—The next position for progressive external rotation is for the recumbent patient to lie with the elbows close to his side and then to swing out the palm of the hand until it faces

7

the ceiling. These movements give some pain after early injury and are therefore not always carried out thoroughly. This is one reason why subsequent elevation is so difficult to secure. About 80 per cent. of the total movement is possible in this second position.

FIG. 117.

FIG. 118.

External rotation and abduction.

(Fig. 119.) Double arm exercises using wall-bars will combine weight-traction and rotation. The patient faces the wall-bar, keeping the body as flat as possible against it. He grasps the bar above his head and takes a slack knee-bending position, pulling

FIG. 119.—Traction and rotation.

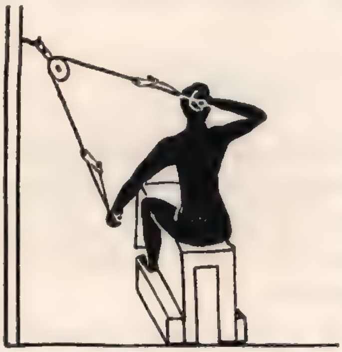


FIG. 120.—Auto-assisted external rotation.

hard on his arms. This puts tension on the shoulder capsule. To progress the treatment the patient repeats this series of movement standing with his back to the wall-bar, with the arms rotated out and abducted. With feet in the second bottom rung and arms at shoulder level the patient facing the bars can hang away from the

bars and obtain an excellent arm exercise which is again a progression to the above.

Auto-assisted exercises (Figs. 120 and 121) with the use of pulley and rope are useful to employ in order to obtain good

FIG. 121.—Combined sling-and-pulley arrangement *to assist* outward rotation.

(Arranged by John Colson, M.C.S.P., of Berry Hill Hall Rehabilitation Centre.)

rotation. These self-assisted exercises have a very definite effect upon the joint, and should be interspersed between the other active exercises. Alternatively with the patient in sit-lying and the pulley attached to a wall-bar at a point level with, but behind

the patient's head, a maximum elevation and rotation is obtained at the same time. (Fig. 51, C.)

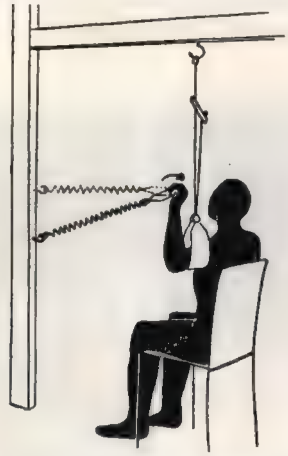


FIG. 122.—How to obtain *a resisted outward rotation.* The upper arm is supported in suspension. Suitable resistance springs are hooked to the wall at different levels so as to obtain various ranges of movement.

IV. REGION OF THE HAND

Anatomical Hand Exercises

A simple method of teaching selective and anatomical movements to patients with hand injuries is to make use of a medium, such as silver sand. The sand should be warmed and placed in a tray about 4 in. deep, and large enough to accommodate several hands at the same time. The exercises can then be " played " in a competitive manner. The movements should first be learnt with the sound hand as a preliminary to treatment, so that the particular use of selected muscles can be understood by the patient.

Where sand is harmful and irritating to the skin other substances can be substituted, such as beans, lentils, or glass beads. These would be kept in a small bowl and used singly by patients.

In a case of senile disuse-atrophy, this method has been used with great success. Lentils were placed in a small bowl, and the patient played and fingered with the slippery seeds for a few minutes of every hour throughout the day. It was interesting to

note how quickly some tone and function was restored. There is a fascination in handling a bowl full of some slippery substance. Larger objects, such as glass beads, are useful, as they can be easily sterilized, and are therefore suitable for cases where the skin is broken or burnt.

Sand exercises are also very useful for footwork. A great deal of movement can be obtained for the lumbricales and muscles of the longitudinal arch with this method. Group treatments can be usefully arranged. The patients should be seated round a shallow wooden trough half filled with sand ; active toe and foot movements can be kept up for much longer periods in this medium than is usually tolerated with other exercises.

Hand Exercises

Two or more patients should be arranged to compete against one another or against the physiotherapist.

(1) *To work all the muscles used in gripping* (Fig. 123).—A handful of sand is grasped, the hand is raised, and as the sand slips out the grasp will tighten to retain it.

(2) *The interossei* (Fig. 124).—The hand is placed on the sand, with the fingers abducted. As much sand as possible is picked up and held between the adducted fingers, as the hand is raised.

(3) *The index finger and thumb.*—Sand is picked up with these two digits and held as long as possible, or rolled between the fingers.

(4) *Opponens pollicis and minimi digiti* (Fig. 125).—An attempt is made to pick up the sand with the thumb and little finger.

(5) *Flexion of first and second digits.*—Holes can be scooped in the sand with the first and second fingers only.

(6) *Muscles of the hypothenar eminence* (Fig. 126).—A handful of sand is grasped with the thumb uppermost ; the ulnar muscles must function to prevent the sand from slipping out of the hand.

(7) *The lumbricales.*—The sand can be swept into heaps by lumbricale action while the fingers remain extended.

(8) *The grip, with pronators and supinators of forearm* (Fig. 126).—A handful of sand is held, and liberated in small quantities in a

FIG. 123.—Gripping tightly to hold the sand.

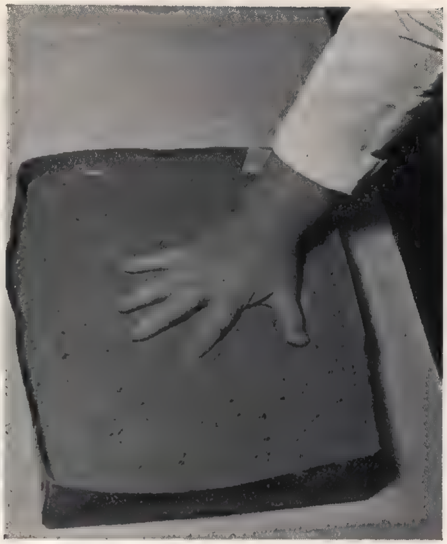


FIG. 124.—Abduction and adduction movements.

FIG. 125.—The opponens in action.

FIG. 126.—Encouraging a tight grip with the ulnar muscles.

circular movement, as if icing a cake, by using pronation, supination and arm movements.

Exercises 1, 6, 8 are good for improving the grip, and are most useful for the after treatment of Colles fracture; 2, 6, 7 for use in ulnar paralysis and paresis; 3, 4, 5, 7 for median paralysis and paresis.

For spastic cases the patients could work in groups in the following ways:

(1) Filling up tins and flower-pots with sand;
(2) Making sand patterns over tracings on cardboard;
(3) Making sand castles with damp sand and decorating them.

Considerable dexterity is required to play these sand exercises well, and it is most important that patients should be supervised and encouraged so that the work is anatomically accurate.

(Fig. 127.) This little folding apparatus is designed for hand treatments. The slings are made of chamois leather, and fasten to adjustable cords, which are suspended by springs; the springs form resistance units. A number of screw-hooks on both the vertical and horizontal frames allow of many adjustments in either direction, or, as shown in the illustration, they can be used as *fixation points* so as to isolate the actual part under treatment. Example: the thumb is fixed in abduction, the wrist is strapped to the extension board under the forearm, and the third, fourth and fifth fingers are abducted from the working finger. The patient's whole attention is then given to the movement of the terminal phalanges of the index finger.

Patients will redouble the effort to concentrate on movements if a result can be seen. A useful exercise was invented by Dr. Kellett-Smith during the 1914–18 war. It is carried out in the following way. Bottles containing coloured fluid are arranged in two rows connected by a glass tube, the lower row contain the coloured fluid. A glass tube runs vertically up the wall from one bottle to the other. The power to pump is supplied by a bulb and tubing on the lower bottles; a tape measure nailed on the wall alongside the vertical glass tube can be used as an indicator. The patients then compete with each other to see how far and how fast the coloured fluid can be pumped upwards from one bottle to

the other. In this way a great amount of energy is put into the act of gripping, and the patients enjoy the competition.

(Fig. 128.) A rubber band placed round the fingers will give good resistance to the fingers for abduction movements. This can be carried about by patients for home exercise.

A bandage roller is a useful piece of apparatus with which to encourage flexion and extension of stiff fingers. As it is activated

FIG. 127.—Miniature spring suspension apparatus for re-educating finger movements.*

by the patient himself no harm will be done. The injured hand is slipped into a cotton glove (housemaid's type) to which is sewn extension pieces for each finger so that they end in a ring about $2\frac{1}{2}$ in. away from the finger-tips. This ring is fastened to a small screw-eye screwed into the roller. The patient winds up the slack

* This apparatus was made by a student of the Swedish Institute, Miss Mary Troup.

end until the fingers touch the roller; then he grips the roller and tightens up the glove with the winder until the limit of movement is reached. By reversing the glove an extension of the fingers can be obtained.

Mr. Handfield-Jones' little weight-and-pulley finger exerciser is continually in use in the massage department and fracture clinic of St. Mary's Hospital, W.2. It is illustrated in Fig. 126, in his book *The Surgery of the Hand*; he writes: "In times of forced inactivity we are apt to be amused with little things; this can be put to advantage by the use of machines for exercising and strengthening muscle." His advice to his patients is: "Make movement the hobby of your convalescence."

FIG. 128.

Another useful "home" exercise for stiff fingers and weak grip is to carry in the pocket a length of watch-spring steel. A strip of this, about 16 in. long, will curl up in a convenient circle, which can be clasped by the hand, and allows of compression and relaxation movements.

FIG. 129.—Typewriter exercise.*

Games.—Various games can be carried out with counters, jumping the counters one at a time into a bowl, as in the game "Tiddlywinks," or flicking cotton-wool balls through goal posts; an excellent movement for isolating the extensors. Plasticine models for those who can make them are always fascinating; also gripping a ball involves work for most of the muscles of the hand. An obstacle race with a ball sometimes creates interest. It can be

* From *The Surgery of the Hand.* R. M. Handfield-Jones.

rolled up and down a table with the hand held flat, then round, or through a series of obstacles which are placed on the table. This will involve movements of the whole arm. All these games are, of course, played in competition.

Rope plaiting, needlework, crochet and knitting " show results " after a spell of effort. Soldiers enjoy needlework. During the 1914–1918 war it was a common sight to see the wool and embroidery shops in towns near the convalescent camps crowded with soldiers buying their pieces of fancy work, and decorating gaudy cushions and canvases for their " home front."

V. REGION OF THE HIP

The paramount importance of strong gluteal muscles is well shown in the diagrams of the common actions of this muscle. The upright posture cannot be maintained if this chief link between the trunk and the legs is damaged ; walking with weak glutei becomes

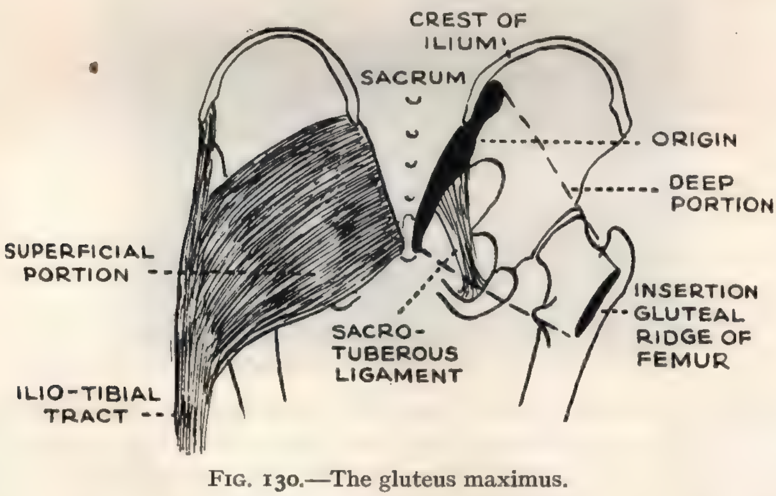


FIG. 130.—The gluteus maximus.

a matter of pure lateral balance on the femoral heads. Patients with poliomyelitis, when these muscles are severely affected, can only get upstairs in a sitting position, by raising themselves with their arms from stair to stair.

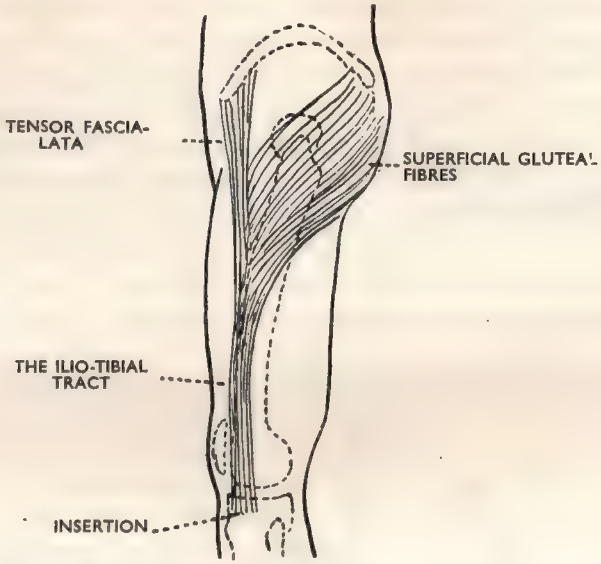


FIG. 131.—The ilio-tibial band is a stabilizer of the knee joint. Note how the muscles brace the fascial band.

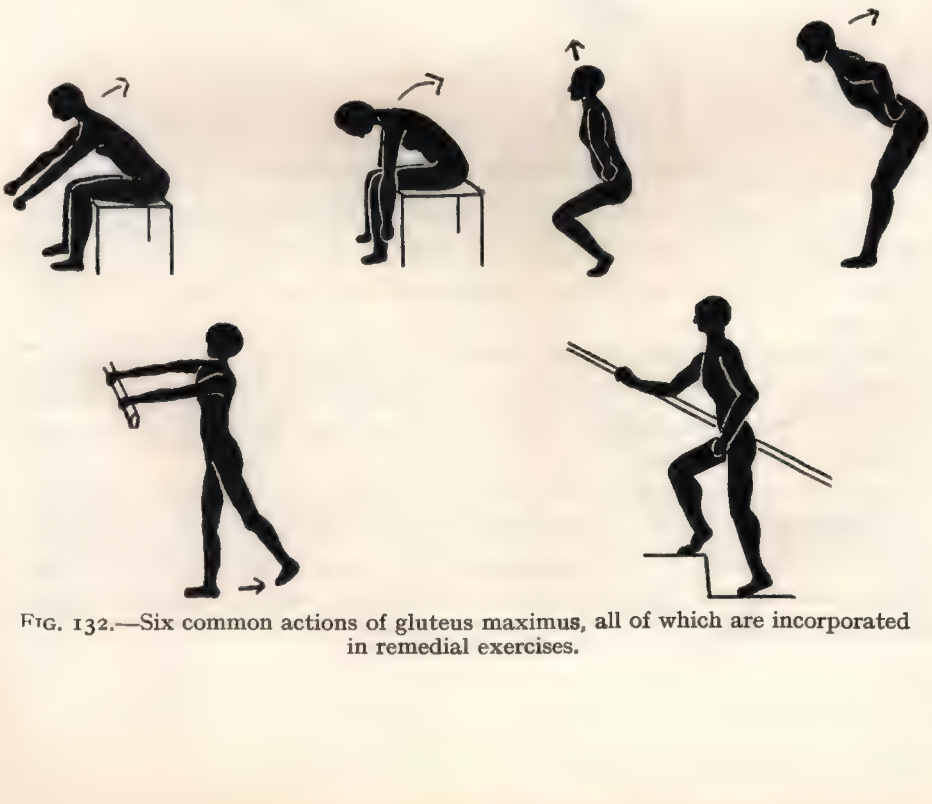


FIG. 132.—Six common actions of gluteus maximus, all of which are incorporated in remedial exercises.

Resistance exercises for the gluteal muscles.—Lying in bed for long periods causes pressure on the glutei and encourages the rapid wasting to which these coarse-fibred muscles are already too prone.

Recumbent patients should turn to prone-lying position to carry out gluteal contractions—if it is possible for them to move into this position. The relief of pressure accompanied by active contraction will do much to assist the blood supply to the muscle. If massage can be applied, so much the better; the "co-operative pressure" method is particularly advocated to produce tone as well as a better circulation. (See chapter on "Massage," p. 385).

FIG. 133.—Weightless but resisted exercise.

For bed cases a thrusting action against the resistance of a strong helical spring is easily arranged, and is a very practical method of exercising these important muscles. (See "Eutonic Exercises.")

The following exercises all show straightforward localized work —simple contractions in various ranges of movement. In each case the isolation of the working muscles, by good gymnastic positions, is essential.

Fig. 133 represents a combination of suspension and resistance by pulley and weight. The pulley must work at right angles to the moving limb. This arrangement is only suitable for short range movements chiefly in the inner range, and is used for cases of paresis of muscle.

(Fig. 134.) Long-range resistance of the hip extensors against resistance of pulley and weight. Hip mobility and muscle strengthening against the resistance of a known weight.

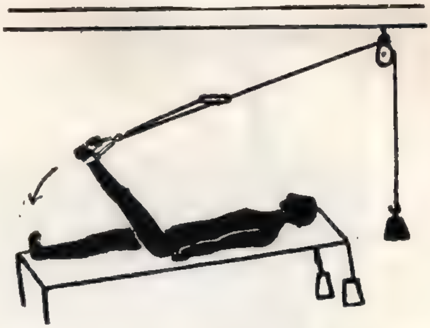


FIG. 134.—Pulley-and-weight resistance.

(Fig. 135.) An alternate fixation; with the advantage that as the effective pull of gravity on the limb increases, so also does the force of the spring increase.

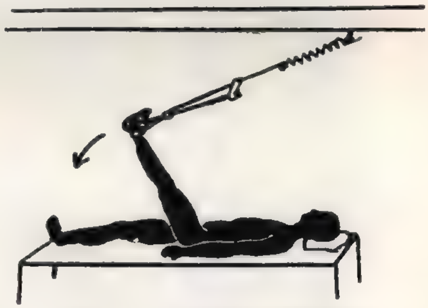


FIG. 135.—Spring resistance.

RESISTANCE EXERCISES

Hip and trunk extension against spring resistance (Fig. 136).—The work is well isolated by the large base and body-belt support. Two strong springs in parallel would be suitable for the average female patient (two 40-lb. springs).

This arrangement is good for group treatments: five or six patients can sit in a row and keep time, all working together. Used for treatment of kyphosis, spondylitis, weak injured backs, weak glutei, and for poliomyelitis cases.

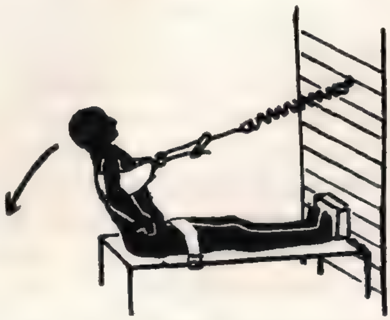


FIG. 136.—A useful back exercise.

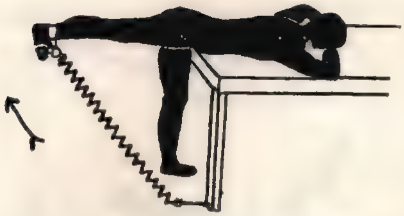


FIG. 137.—Spring resistance.

FIG. 138.—Pulley-and-weight resistance.

(Fig. 137.) A table will serve to isolate the hip-joint extensors while they are worked against the resistance of a strong, pliable spring. The spring is fastened to one of the table legs. (A home treatment.) Note how the knee joint is braced by all the actions which involve the gluteus maximus in strong actions.

(Fig. 138.) Hip extensor work against pulley and weight. The grasp position helps to localize the muscle-work to the weak muscles.

For ward patients an essential exercise is *leg thrusting*, involving both hip and knee movements. (These are illustrated in Fig. 165).

The synergic actions of muscles must be brought into use for all re-education treatments whenever possible; for instance, such muscle-work will take place in connexion with movements of the levator ani, and other muscles of the pelvic floor, if the patient is properly instructed and abdominal retractions and pelvic contractions are carefully practised. All these methods of treatment of the glutei should be made use of, especially for cases of paresis or paralysis, as *these indirect actions may start impulses* which will cause more direct actions of the muscle as a prime mover in course of time.

Simple suspension of the limb may have to be continued for selected cases, and then resistance applied in the horizontal plane. In this way the muscular effort required for *mere support* of the limb is eliminated; the entire physical effort is isolated and expended on the muscle-group under treatment.

Unless the range of movement is very large, resistance can be supplied by helical springs, because of their very small weight in relation to the force that they may be made to oppose. Where

FIG. 139.—Resistance for the abductors.

Combined sling-and-pulley apparatus used for the treatment of a fractured pelvis with drop foot in a patient at Berry Hill Hall. This illustration is lent by John Colson, M.C.S.P. Note the way the angle of pull has been thought out.

the range is large or where it is desirable to oppose a constant (instead of a progressive) resistance, resort is made to weights, application to the limbs being by way of a rope passing over one or more pulleys.

Fig. 139 shows how to combine suspension and resistance for the hip abductors.

VI. REGION OF THE KNEE

Of all treatments in physiotherapy one of the most difficult is that of regaining movement in a knee joint which has been septic and has become stiffened. The secret of success is early movement, but it must be of the gentlest type. Moreover, the movement must be *active*, so that joint and muscle regain consciousness together in *natural* movement. The methods suggested here are effective and adaptable to many conditions and are easily set up to allow of frequent use, at intervals throughout the day.

The knee muscles.—The quadriceps will always waste if the lower limb is immobilized for any length of time; therefore the sooner physiotherapy can be applied the better it will be for all the "soft" structures which are so important for the control of the joint.

A group of exercises is submitted which can be graded from very easy assisted exercise to strong resisted exercises well localized to the inner range of muscular activity.

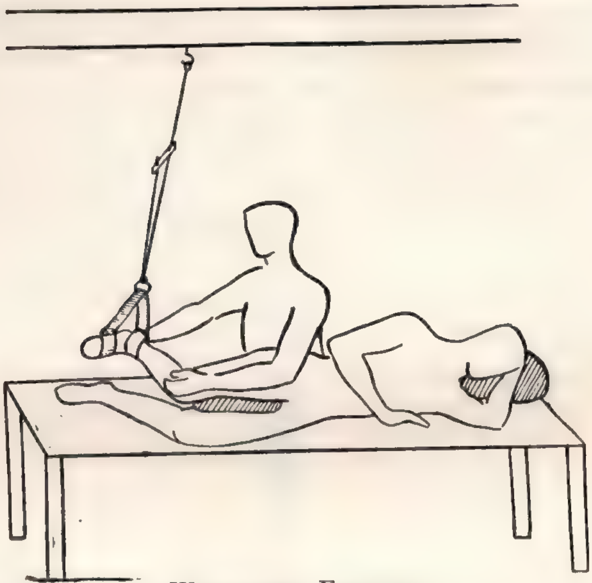
For still further mobility and muscle-building exercises the reader is referred to the section on "Pulley Therapy," where it is shown how to obtain absolute *maximum work* for this group of muscles against the resistance of heavy sandbags as weights.

Precautions.—Muscles which have become involved in a compound fracture and have suffered laceration will tend to adhere to underlying bone or fascial layers near the bone. Such muscles must not be overexercised; some surgeons order complete rest until the ambulatory stage of treatment is reached.

Resisted Knee Exercises

Fig. 140 represents a useful position which has been used over a number of years for the treatment of knee injuries, such as fracture of the patella and excision of cartilage, also for selected cases of arthritis.

The thigh is supported from below by a hard cushion, and *must* be held firmly by the operator. The quadriceps is strengthened by extension movements, free swinging or resisted manually. The



WEIGHTLESS EXERCISE

FIG. 140.—Knee extension exercises, active and isolated by operator's hand and a hard cushion.

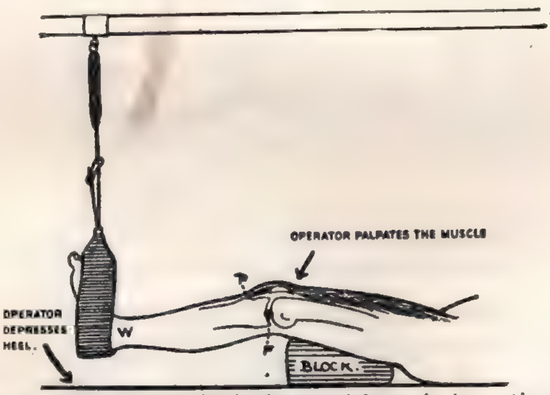


FIG. 141.—Shows how to " assist " the quadriceps in its action against gravity.

range of the movement can be gradually increased ; the pivot of suspension should be placed directly over the knee joint.

Spring exercises for quadriceps.—In Fig. 141 the " assisted " method detailed in Chapter X is repeated.

In Fig. 142 a resisted exercise to work the quadriceps in the inner range is shown. The knee is pressed downwards against the

resistance of a spring. The muscle-work is concentric, and eccentric, should the patient control the recoil of the spring.

If the quadriceps is weak the patient may tend to cheat by using the extensors of the hip ; this can be prevented by placing a second light spring *on tension* to the rope supporting the foot.

The arrangement of this exercise lends itself to group treatments, as the exercise is simple and easily supervised. Each patient should watch the movement of the spring as it is pulled out by his muscle contraction; this tends to hold attention and make for better work.

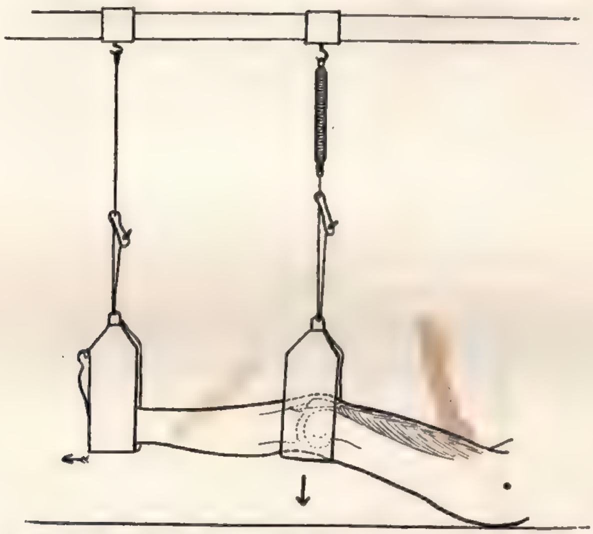


FIG. 142.—Spring resistance for muscle development in the inner range of the quadriceps action in order to produce the fullest possible extension.

For group treatments it is best to arrange the patients in a row ; if they then keep time together (one being the leader), supervision is greatly assisted and the work goes with a swing.

An alternative arrangement is suggested in Fig. 143 for use when only very small joint ranges are possible. Such conditions arise after extensive lacerations of the soft tissues with adherent scar tissue. It has been found that with this arrangement of a light and very flexible spring placed over and supporting the joint, with the foot and femur relatively fixed, as illustrated, a small amount of movement may be gained within the limit of the joint structures,

when the muscles are put into contraction. Any slight movement will be beneficial and will make a start on which to build up further activity. This spring-balance effect placed so as to support the joint, appears to assist the muscles to get a pull on their insertions near the joint.

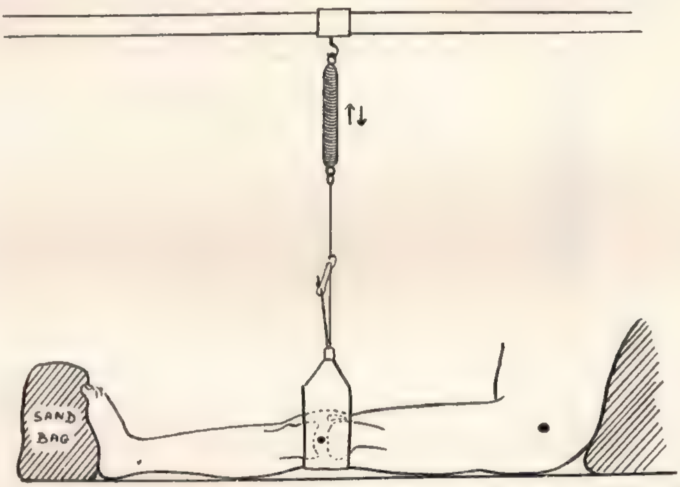


FIG. 143.—Arrangement to facilitate movement in a very stiff knee joint.

Various other combinations of these springs will give interesting treatments ; for instance, the assisted and resisted spring exercises (Figs. 141 and 142) *can be combined,* and are used in this way : they are described in the chapter on " The Fracture Clinic."

FIG. 144.—Pulley-and-weight resistance for the quadriceps.

Resisted exercise for quadriceps against a known resistance, also used as a testing exercise. A simple pulley-and-weight arrangement is shown in Fig. 144. The patient is placed in a

starting position which ensures correct isolation and correct performance. A canvas bag filled with sand makes a good resistance if heavy resistance is required—otherwise, a tin with lead shot is convenient, and can be easily altered to grade the different weights. (A spring-balance should always be at hand so that the weight can be graded and recorded.)

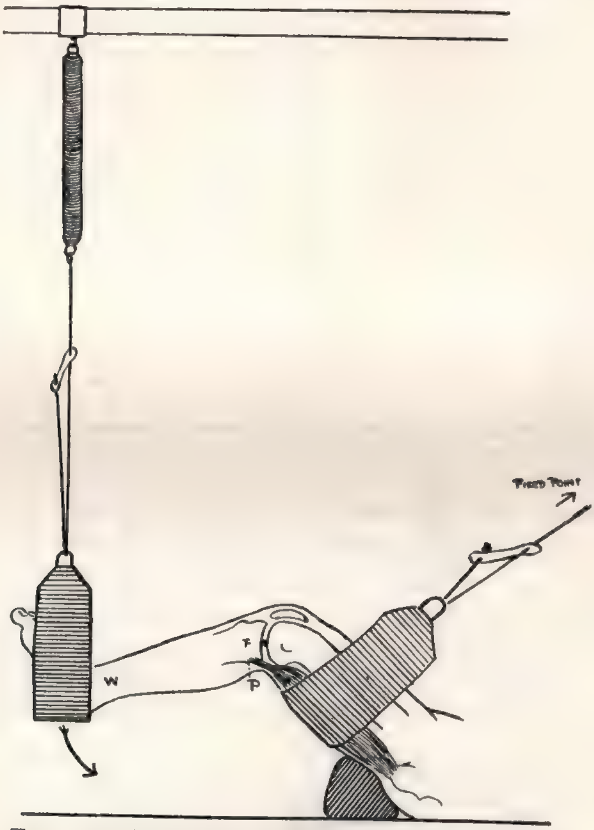


FIG. 145.—Resisted exercise for the hamstrings.

Precaution.—If the quadriceps is overexercised a patient may develop genu re-curvatum. Occasional muscle-toning exercises to the hamstrings will greatly reduce this risk.

With the arrangement shown in Fig. 145 two different exercises can be carried out without altering the fixations, as illustrated, and are described as follows.

(1) *To resist the flexors and to increase the range of flexion of the knee.*—The patient concentrates on pressing down the heel against the extension force of the spring, and controls the return or recoil. This will put the hamstrings through a second dose of exercise or eccentric action. This arrangement of patient and muscle-work makes a resisted movement possible in a recumbent position, that would otherwise have to be carried out in prone-lying.

If the gluteus maximus comes into play, the muscle can be checked by placing a sandbag under the hip region, as indicated.

This hamstring exercise can be equally well carried out with pulley-and-weight apparatus, but then the mattress of a surgical bed will have to be adjusted to allow for the range of movement.

(2) *To increase the range of movement and strengthen the muscles of the knee joint.*—If the flexor and extensor muscles are worked alternately, a partly assisted and partly resisted exercise results. The femur is now supported at an angle favourable to movement. The support is a sling belt firmly fastened to a point behind the patient's head. The lower leg is balanced in suspension. The spring recoil will assist the *quadriceps* if this muscle action is carefully "timed" to work with the spring. The hamstrings work against the resistance of the spring, but have gravity in their favour.

This exercise is useful for increasing range of movement and muscle tone when a patient is first out of plaster, after such an injury as fracture of the tibia.

VII. REGION OF THE FOOT

Rehabilitation of the Foot after Trauma

Generally speaking, before starting exercises the foot should be rendered as warm and supple as possible by soaking in hot wax or hot water. This is also a useful preliminary to massage and passive movements which should precede active movements.

Contrast baths are excellent for stimulating the circulation. Placing the feet in buckets of very hot and cold water alternately is a simple manner in which to carry out this method.

The most perfect "contrast bath" was installed in the ortho-

pædic hospital at Frankfurt-on-Main a few years ago. It may be of interest to describe this bath, as some very good features were incorporated, and the writer was invited to try the treatment in person.

The bath consisted of a long porcelain trough with a hand-rail. The trough was just wide enough to hold both feet side by side while standing. One end of the trough was 2 ft. deep, with extremely hot water. As one walked along, the trough sloped so that at the far end it became shallow and the water cold. The bottom of the trough was covered with different substances, starting with mud, then sand, followed by pebbles, changing to sharp gravel. The foot muscles were thus constantly stimulated by walking on these different ground surfaces, and balance had to be maintained, owing to the narrowness of the trough. After two or three excursions up and down the 15-ft. trough the peripheral circulation was found to be stimulated to such a degree that the skin was deeply flushed, and the tingling sensation that was set up remained for some hours.

It is therefore suggested that sand and small stones might be placed at the bottom of the hot-and-cold water buckets used for contrast baths, so that the toe muscles could be activated by gripping the substances under the water.

Manipulations.—It is well known that after trauma all the soft tissues and small joints should be mobilized, if possible, before active movement is begun. It is usual to deal with each joint in turn, the sub-astragaloid and mid-tarsal joints being the most important ones to mobilize, if there is to be any comfort and adaptability of the foot when walking on rough ground.

The following manipulations are useful to give :

(1) Grasp back of heel, place hand on dorsum and strongly plantar flex ;

(2) Still grasping heel, the outer border of the foot is held, with the thumb on the dorsum, and the fingers on the sole ; adduct the fore-foot and invert the heel.

(3) Reverse the process ; give full eversion of heel and abduction of the fore-foot.

(4) As in (1) but dorsi-flex, with the palm of the hand on the sole of the foot.

Dr. Mennell in *Physical Treatment* advises a full pronation and supination of the fore-foot, while supporting the hind-foot at the level of the mid-tarsal joint ; the fingers of the supporting hand reach as far down the os calcis as possible, and press it slightly away in the opposite direction.

A further useful free movement that the patient can do for himself, and one which will prevent or break down adhesions which may lie on the dorsal aspect of the foot, is carried out by the simple expedient of sitting on the plantar surface of the foot, so that the dorsum is stretched by the body-weight. An ordinary plinth or chair can be used for this purpose, and it is a useful exercise for a " follow-up " treatment after a forcible manipulation by the surgeon.*

Toe work.—Toe movements become very important when considering the treatment of injuries classed as " below knee injuries." The *long flexors* and extensors of the toes must be vigorously exercised, as they will first of all activate the toes and then react throughout their length. Their energy will be transmitted up the whole shaft of the lower leg bones to their origins. As the ankle joint is immobilized in such cases no movement will take place at the joint, but tendon adhesions will be prevented and muscle-tone will be kept up as far as the knee.

The *short muscles* (intrinsic to the foot) must be moved constantly in order to keep up the local tone of the foot, and its arches.

Disuse atrophy quickly occurs in the intrinsic muscles of the foot unless great care is taken to bring these muscles into frequent use and to awaken an interest in their existence in the patient's mind and so establish muscle consciousness. Faradic baths are used for this purpose and active movements should be superimposed on the artificially produced movements, in order to obtain a maximum effect.

There are two exercises that are usefully employed : *one* is to press all the ten toes against a board so that a purchase is available from a fixed point ; with this to help, rhythmic movement is carried out from below upwards which involves the lumbricales and interossei so that they raise the arch of the foot *without* long flexor and extensor action. Complete relaxation should follow

* Self-traction apparatus to assist dorsi-flexion is shown in Fig. 157.

each such movement. On no account must the long flexor and extensor muscles be allowed to " take charge " in this exercise.

Secondly, and to make a variety, the toes can be held as straight as possible, while the metacarpo-phalangeal joints are alternately bent and stretched over the edge of a book. This exercise clearly brings the lumbricales into use by isolating them as flexors of the proximal joint. As the toes are held straight by other muscles, the movement will be found somewhat fatiguing, and after some movements a rest should be taken.

Spring-resistance Exercises for the Foot

These foot exercises are designed to be carried out with variable resistances which can be easily graduated by choosing different springs. By increasing the strength of the spring, and by repeating the exercises more often during the day, a very satisfactory degree of exercise can be administered.

To rehabilitate the muscles of the lower leg, and to give variety in treatment, various exercises are suggested which can be carried out by groups of patients or employed for ward patients.

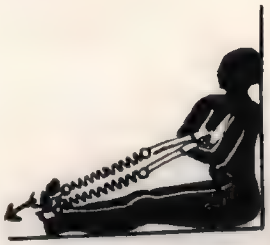
FIG. 146.—Resisted dorsi-flexion.

FIG. 147.—Resisted plantar flexion.

The ankle joint (Fig. 146).—A useful dorsi-flexion device for patients in the wards. The spring is fixed to the bottom of the bed, and a strap loop is fastened to the patient's foot. He is encouraged to move the foot against this resistance, and to continue the exercise from time to time throughout the day.

(Fig. 147.) To plantar-flex the foot, the spring device is fastened with an adjustable rope to the head of the bed ; the plantar flexor muscles will then press down the belt against the resistance of the spring.

(Fig. 148.) The patient creates his own fixation by passing the looped end of the apparatus over his crossed forearms ; the other end is placed over his feet, and the springs are attached between these two points. The plantar flexors work in stretching the spring ; both feet work at the same time.



THE MID-TARSAL JOINT.

FIG. 148.—Bilateral plantar flexion.

FIG. 149.—Resisted inversion.

(Fig. 149.) The patient sits with his legs crossed, and inverts the foot (which is raised from the ground) against the resistance of a light spring ; fixation is provided by the other foot and leg.

(Fig. 150.) A double eversion arrangement ; the thighs must not be allowed to rotate out, and should be held by the patient, or

FIG. 150.—Double eversion.

FIG. 151.—Resistance for the quadriceps.

alternately the patient should sit so that the knee joints are in flexion.

(Fig. 151.) An arrangement suitable for strengthening the quadriceps muscle of the upper leg, by practising extensor move-

ments in the inner range of movement. The lower leg supports the resistance spring.

If the spring and foot-belt is arranged with care, combined lateral and up-and-down movements can be brought under resistance according to the need. For instance, dorsi-flexion and inversion can be carried out at the same time.

Group treatments.—It is sometimes very convenient to group patients with similar injuries, so that they can do their exercises together, and encourage each other by so doing.

These foot-resistance exercises make good group-work, as the muscle-work is isolated in some of the exercises, and the starting positions are well fixed, hence supervision is made easy.

FIG. 152.—Training the abductors of the toes.

The type of spring used for this work is not a high-grade sports spring, but a tension spring such as is supplied by a motor-car factor, and sometimes called a "check spring." A spring of suitable tension must be selected and care taken to see that the belts and fittings are comfortable and easily fixed. It is visualized that patients will be employed for long periods in the gymnasium, and that variety of exercise is one of the most important features of the new idea of rehabilitation; it is felt that this little group of exercises interspersed with sand exercises, such as are described for the hand, will be found both useful and effective.

Active work.—All kinds of good active movements, which aim at making the feet more "intelligent" should be thought out.

Ping-pong balls can be gripped and held; all types of flat-foot exercises and muscle training of abductor hallucis, lumbricales and interrossei can be carried out (Fig. 152).

Careful rocking exercises should be given in preparation for weight-bearing and walking. Foot movements require thoughtful analysis, as patients rarely have any appreciation of fine movements of foot or ankle. It is more interesting, and leads to more exact work if the physiotherapist also thinks out the leverage of the movements, while supervising these exercises.

Three orders of leverage are illustrated in walking movements (Fig. 153).—The foot is first swung forward from the hip and

flexed by tibialis anticus ; then the heel is lowered to the ground to take the weight (third order lever) (Fig. 153, A).

Secondly, the foot rocks forward from heel to toe as the body-weight falls forward (first order) (Fig. 153, B).

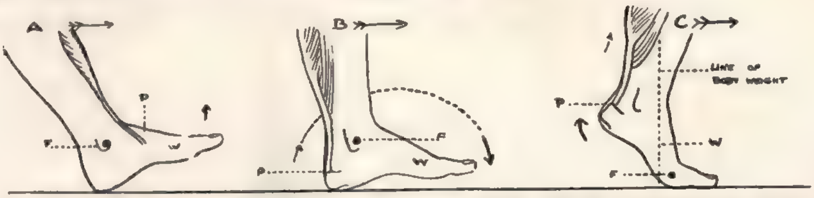


FIG. 153.—The leverage of foot movement when taking a single step as in walking.

In each diagram F=fulcrum ; P=power ; W=weight.

The movement ends with the toes, chiefly the big toe, balancing the body-weight, and the ground is pushed behind as a forward progression takes place, so that the tips of the toes only remain on the ground (second order) (Fig. 153, C).

TRACTION EXERCISES. STATIC : KINETIC

Traction is always good for the joints ; it affords a sense of relief from pressure, and is a unique form of exercise for this reason.

The spine.—There are various forms of Swedish head-suspension apparatus on the market.* Further useful apparatus is suggested, and an illustration is given which may help to amplify head and spinal treatments that can be given with traction (Fig. 154).

Counter-traction by means of weights.—Hand-bars are not necessary, nor any handling of the patient by the physiotherapist once the correct position and weights are found, as the whole system is self-adjusting.

The patient must be weighed, and a weight half the equivalent of this weight should be attached to an adjustable rope passing through two pulleys. One end of the rope is attached to a head stall and the other to a weight which is balanced a short distance above the second stool. If the patient raises himself or stands up, tension can be relieved, and the weight will rest on the stool. As the patient progresses the time of stretching will vary from 5 to 20 minutes. The aim is to lessen the weight gradually, so that in

* Swedish head-extension apparatus gives good traction but *not* suspension.

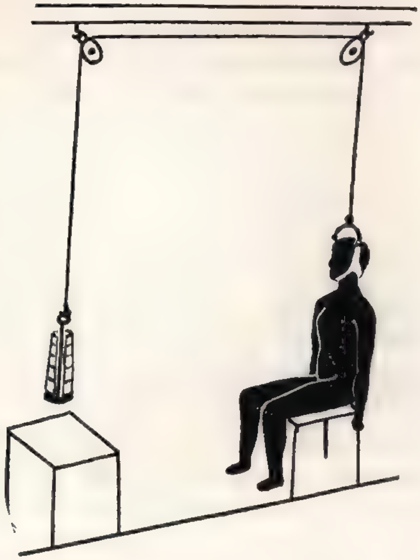


FIG. 154.—Head suspension and counter-traction by weights, as arranged by Dorothy Talbot, M.C.S.P.

SELF-TRACTION AND MOBILITY FOR THE SPINE

FIG. 155. Side flexion exercises. FIG. 156.

(I am indebted to Dr. Bellis Clayton for these photographs which were taken for me at King's College Hospital.)

time a good position can be maintained without any weight at all. Free arm movements can be added to the stretching. Deep spinal pressure can be given with good effect while the structures are stretched by tension. The operator then supports the patient's head with one hand while the pressures are applied with the other.

An alternative head suspension can be arranged as in Fig. 83. In this case we have the advantage of self-activated movement which is carried out against the resistance of suitable springs of moderate tension. Longitudinal traction is given by the physiotherapist.

(Figs. 155 and 156.) These contrasting pictures show how to obtain mobility in different regions of the spine. The dorsal region is always difficult to isolate; it will be noted that by altering the position of the arms to half-yard, half-stretch, the side-flexion movement is taking place much higher up the spine in Fig. 156 than it is in Fig. 155.

The Ankle Joint

Powerful self-traction apparatus for the ankle joint and for stretching contracted calf muscles.—The author has designed an apparatus which has been in use for many years, and has been copied by several of the larger hospitals. With this device the patient is able to stretch his own joint and calf muscles without putting tension on the plantar fascia of the foot.

The ankle joint may become stiff after injuries of the lower bones of the leg, or from actual ankle and foot injuries. Adhesions form which hamper full dorsi-flexion, and free movement is difficult to obtain.

The illustration shows a view of the apparatus, which can be easily supported by a pin socket to any strong upright in a gymnasium (Figs. 157 and 158).

The apparatus consists of a framework of two upright pieces of wood, connected by a cross-piece about 8 in. wide; the uprights stand about 2 ft. 6 in. high. To the centre of the cross-bar is hinged another piece of wood, $1\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. and about 12 in. long. This timber fits into a socket which is made to hold it, such as is

found at the ends of a boom, and is pinned by a long nail or bar, so that it can easily be taken away if desired. Stops on each side of the uprights are necessary to prevent the whole from collapsing.

(Fig. 158.) A leather boot with a long leg piece is fastened to an 18-in. board. This board is swivelled on to the uprights by a pivot. The pivot is designed to allow the board to swing, but its axis must be *in line with* the axis of the ankle joint; thus the movement of the board and the ankle joint will be synchronized, and no strain will be felt at the sole of the foot. The boot is cut

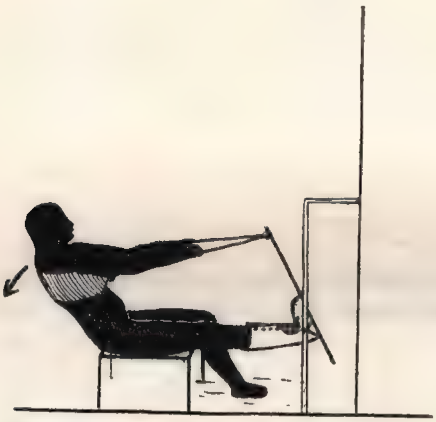


FIG. 157.—The author's self-traction apparatus to encourage dorsi-flexion of the ankle joint.

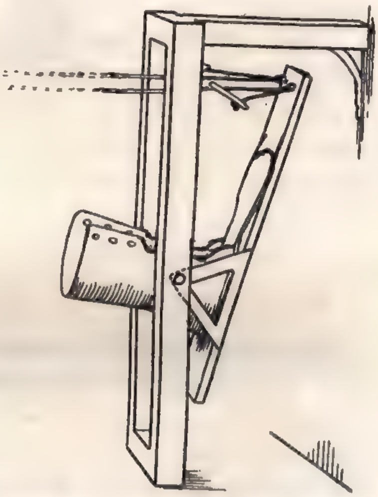


FIG. 158.—Detailed view of the apparatus.

away near the ankle to allow for dorsi-flexion of the joint without discomfort; the upper part of the boot is laced up the front of the leg.

(Fig. 157.) The patient sits on a low stool, so that the line of the femur and tibia is continuous with the ankle joint when the foot is in the boot. The canvas belt is placed round the upper back, and the ropes adjusted by wooden cleats; the ropes are attached to the top of the 18-in. board; in this way a powerful leverage is obtained by the patient, who uses his hip and back extensors to dorsi-flex his ankle joint.

Kinetic traction.—The recoil action of a spring can be used for a dual purpose :

(1) To *assist a muscle* to lift the body weight or the weight of a limb against the force of gravity ;

(2) To obtain *kinetic traction* by means of which a joint can be moved in all axes and planes of movement and in a full range. The effects are strong if a strong spring is used, as the accumulated energy which is stored up in a spring is released when a spring is placed on tension and then allowed to recoil.

FIG. 159.—*Vertical traction for the hip joint,* applied in line with the long axis of the femur by overhead ropes and belts which support the lower leg ; assisted or resisted rotation movements are then carried out (arrangement by Margaret Roper, M.C.S.P.).

(Fig. 160). With this apparatus we can obtain a useful *traction* exercise, which is easily set up and which is suitable for some remedial treatments, but which is definitely contra-indicated in others.

To illustrate the action, we will imagine a patient suffering from pain in the neighbourhood of the shoulder, diagnosed as fibrositis ; a mild adhesion is suspected after some trauma. The patient is

ordered short-wave therapy, massage, passive and active movements.

To arrange the exercise a selected spring (say, 30-lb. spring) is hooked to an attachment on the wall about 7 to 8 ft. from the ground. For preference the patient should sit across a gym stool —to fix the pelvis—and turns so that his back is to the wall at a distance of about 3 ft. At first the operator should pull down the spring and control it, and try out the action on the patient's sound arm. The patient holds the handle attached to the spring, and is told to strongly *adduct* the arm. This he will be able to do, even on the injured side. The spring will now be under tension. He then " lets the arm go," the arm following the pull exerted by the spring's recoil. After some practice he may relax or even assist the upward action.

FIG. 160.—Kinetic traction in different planes, useful for treatment of fibrositis but absolutely contra-indicated for orthopædic conditions.

The treatment is then started on the other side. The patient repeats the above actions which he now understands, in this way a good sustained traction will be obtained. If the patient is moved to right or left of this starting position traction is given in different planes so that every aspect of the joint will be stretched; *at all times the apparatus is under the patient's voluntary control.* The strength of the spring should be carefully selected by the physiotherapist so that the recoil movement is not too powerful.

POLE EXERCISES

6. **Poles.**—Another very simple apparatus is a pole, and many useful exercises can be performed with its help. Double-sided actions are so necessary in remedial treatments; the help given by the uninjured side will stir up many associated nerve paths which might otherwise lie dormant.

(Fig. 161, A.) The rod is grasped and rotated first one way and

then the other, the upper arm being stabilized by the other hand, in order to isolate the radio-ulnar joints.

(Fig. 161, B.) The rod adds to the momentum, and promotes a good rotation in the humero-scapula joint.

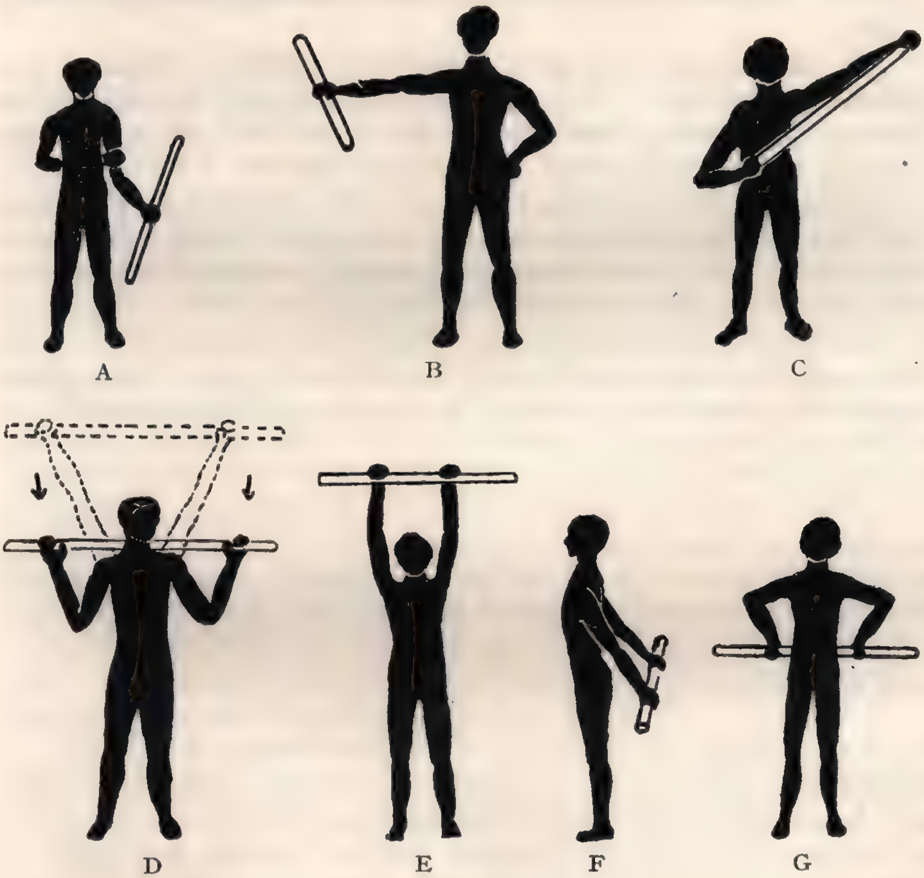


Fig. 161, A to G.—Pole exercises.

(Fig. 161, C.) This is a particularly useful exercise, by means of which the injured arm can be assisted by the good arm in extension and elevation movements.

(Fig. 161, A to G.) All the arm joints and muscles are used in these exercises, including the hand in gripping the pole.

Fig. 161, C to G, are all useful exercises for the hemiplegic

8

patient ; double-sided exercises are most usefully employed for these patients.

Resisted exercises.—Two patients *grip* a pole one at each end. They turn it in opposite directions, thus resisting each other ; a spirit of competition is introduced and a strong gripping exercise results.

The pole is also used as a simple and effective *pronation and supination* machine. The operator holds one end, the patient the other ; each person now resists the other, the physiotherapist varying his strength to suit the patient's efforts.

In trunk rotation exercises the patient sits in stride-stoop position with the arms grasping the two ends of the pole ; as he rotates from side to side the physiotherapist can apply resistance by holding the pole while standing behind the patient.

General class work carried out with poles is attractive to watch and useful for therapy, as the double-sided movements make things easier for patients who have yet to acquire good co-ordination.

Chapter XII

REHABILITATION IN THE WARDS

It is wise to make a complete study of the sick and warded patient from various aspects, before an actual treatment is commenced. In addition to physical illness, certain changes are bound to occur as the result of long continued inactivity.

These changes are, first, *the general reactions* following the shock of surgical interference or long illness, and the resulting prolonged confinement to bed. These may be summarized by stating that all bodily functions are slowed down, the circulation, respiration, and digestion will be affected ; the anatomical structure in the trunk and limbs, and the postural muscles will all suffer.

The circulation.—The heart's action becomes disordered to a greater or lesser degree, the circulatory system loses its power of compensation to sudden calls ; the blood-flow slows down, involving the risk of clot-formation in the veins and consequent risk of pulmonary embolus. The occurrence of clot-formation or thrombi is now generally thought to be due to a slowing down of the circulation ; clots are a serious danger, sometimes causing death. The following notes on thrombi are taken from *The Physiological Basis of Medical Practice*, by Best and Taylor, and the description enables us to visualize the condition.

A *thrombus* is described as a white object (or head) with a dark tail ; the head is directed proximally ; on each side a framework or " ribs " extend from the walls of the vein to the head ; the " ribs " are made of massed platelets, covered with leucocytes ; the tail extends a variable distance along the vessel and is made up of all the elements of the blood—fibrin is plentiful ; the mode of deposition of the ribs or framework is compared to sand deposited in a ribbed fashion on the sea-shore when the current of water is slowed down.

The causes of thrombi are gradually becoming known and appear to be as follows. Injury to vessels, corpuscles and platelets, toxic and micro-organic infections, but above all, the *slowing of*

the blood stream, especially in the lower limbs. It is from this cause that the type of post-operative thrombi, most dreaded of all, may result. The chief causes are enfeebled heart muscle-action, confinement to bed, debilitating diseases, immobility of the limbs, and other factors such as low tissue tension and low metabolic rate. The great danger period is 7 to 10 days after the operation, just long enough for the clot to form from the slowing of the circulation.

The danger of a thrombus causing occlusion of one or both branches of the pulmonary artery is well known. It is said that emboli found after death resemble the structure of the thrombus described above, and are of such a size that they can only be accounted for by their formation in a vessel such as the femoral vein. These facts indicate that a cramped or dependent position of the limbs, complete immobility, or any other circumstances which will enhance or cause retardation of the circulation in the veins of these parts—quite apart from infection or vessel injury—will be conducive to thrombus formation.

The chief means employed in attempts to prevent post-operative thrombus are as follows :

(1) Early movements of the limbs, to favour the venous flow.

(2) Avoidance of any restriction *to respiration*, which is an important factor in aiding the venous return from the limb.

(3) Thyroid extract administration to raise metabolism and increase the circulation rate. Plenty of fluids to prevent dehydration, and the use of anti-coagulant drugs.

These facts stress the vital necessity of early treatment, by movement of the lower limbs and breathing exercises ; it is therefore anticipated that the warded patient may well be ordered physical treatment at an early stage. The purpose of this chapter is to show how, by careful technique, exercises can be graded down to suit weakness, so that the patient need suffer no strain, while at the same time the circulation can be assisted.

Respiration.—One of the sequels of trauma, illness and inactivity is hypostatic pneumonia—a congestion of the lungs, which can only be alleviated by movement of some sort ; frequent turning in bed every few hours is carried out for helpless patients.

Breathing exercises are a most important part of treatment, the immediate purpose being to keep the lungs constantly ventilated. For this end, it is necessary to encourage diaphragmatic breathing, intercostal breathing, and, above all, the bases of the lungs must be expanded and moved. Many records go to show that the chief remedial effect of deep breathing is that the risk of pulmonary emboli is greatly lessened.

The digestion.—The digestive tract is commonly affected. Constipation ensuing on operation is often attributed to the anæsthetic, or to opiates administered to combat post-operative pain ; but it is probably due, at least in the main, to the general slowing-up of bodily functions, as the result of immobility.

Distension and flatulence are also very common results of abdominal operations. Specialized massage on the abdomen will tend to alter the fluid and gaseous tension of the area worked on ; and in practice the treatment is found greatly to relieve these tiresome complaints.

Joints.—In addition to these functional disturbances, there may be trouble with the *anatomical* structures. Stiffness and pain may be experienced in the hip joints, lumbar spine, and sacro-iliac area, as a consequence of prolonged posture in a half-lying position. The normal lumbar curve tends to become obliterated, thus giving rise to strain in the joints of these regions.

Posture.—Good posture is lost by illness and long lying in bed, and strain may occur when a patient gets up if the postural muscles are allowed to become atonic. Therefore it is of the greatest importance that posture should be corrected. The chest must not be allowed to sink in, nor the shoulder joints to fold themselves across the chest. The patient's weight must be evenly supported, not lying on one buttock, and the back must be kept straight. Much can be done towards this by the skilful arrangement of pillows and cushions.

The building up of muscle tone in the anti-gravity muscles is of primary importance in the rehabilitation of the warded patient. A new method of exercising these muscles has been described in a previous chapter under the name of "Eutonic Exercises," and is referred to again in this and the following chapter and on pages 162 and 163.

Disuse changes in patients' hands.—The skin will be atrophic and shiny, and accompanying this there will be a marked stiffness, and possibly decalcification of bone. Disuse will also cause œdema ; this, in its turn, will cause adhesions in the fingers. Gentle active movement persistently carried out is of the greatest importance. Such a condition of the hands and fingers will prevent the patient using crutches, so in lower limb injuries this will be a very serious drawback. The hands should always be looked at from the very start of treatment, and treated by constant gentle active movements, such as are suggested in " Regional Exercises."

The feet also should be examined, the bedclothes being rolled back to below the knees. It is remarkable to observe how seldom a really sound, normal foot appears among hospital patients in England. Examination usually discloses that the muscles of the transverse arch are sadly lacking in tone, and that in consequence the extensors are overacting, even contracted, and the foot is splayed out. The toes themselves may be hammer-type or on the way to that condition ; and the great toe is commonly adducted.

The intrinsic muscles of the toes must be carefully trained, so that flat-foot and a dropped transverse arch will not result from the illness. For this purpose detailed exercises to work the lumbricales, interossei, and the tibial muscles are necessary, and are described in " Regional Exercises." Some of the exercises can be carried out against resistance, others involve training of muscle consciousness by the use of localized tensing methods, or by faradism.

Permission should be obtained so that prophylactic treatment can be carried out as a matter of routine, even if there is nothing functionally wrong with the feet. Once the patient can be made conscious of his disabilities he can attend to the treatment himself, with slight supervision. For that purpose a bed cradle is essential, so that the foot is free from pressure ; an adjustable foot rest should be considered a necessity, not a luxury.

Records.—The restoration of function of joints and muscles is, of course, a major purpose of the treatments with which our work is concerned. The use made of the *angle-measurer* and the tape-measure for preliminary examination in measuring and recording

the range of movement is important ; since without accurate data under these heads the statistics of progress must be unreliable.

After the examination of the patient has been completed, and the doctor's diagnoses and his aims of treatment clearly understood, the *method* of exercise will be the next thing to consider.

Grading of exercises.—In some hospitals the patients are graded to suit the treatment ; in others the exercises are graded to suit the patients. In either case a definition leads to clarity.

After seeing a demonstration of the graded exercises now advocated, including the eutonic series, a well-known surgeon invited the author to start the method in his wards, in a large London hospital.*

The patients in the wards are taken from a cross-section of the public and are in no way a selected group of persons. They include the aged, the very young, male and female, patients. Some are orthopædic, others post-operative cases. The results of treatment have been analysed after a trial, and the following report was made by the two chief surgeons.

These reports are labelled A and B.

Report A.—" I have watched the experiment in rehabilitation which has been carried out since March 9, 1942, in the wards.

" I find, first, that its institution has had a notable effect on the morale of patients : their interest is quickened and held by the simple apparatus of springs and pulleys which are used throughout the day, in one or other part of the ward. Even the very old are pleased and stimulated. There is, I notice, a kind of friendly challenge in these springs and pulleys which brings out and sustains a patient's best effort ; and at times one is even aware that they create a certain rivalry in the process of quick convalescence. The new patient arriving has an early impression of a whole ward working to get well.

" For it has been our aim to include as many as possible in these exercises—by no means limiting them to orthopædic or fracture cases, but extending them to cases of every kind, pre- and post-operative. Patients may thus rise from their beds in good physical condition after weeks and walk far sooner than they would otherwise.

* Mr. A. K. Henry, F.R.C.S.I. ; Wards B. and C. at Hammersmith Hospital, Ducane Rd., London.

"Very striking, too, is the way in which, for example, an amputee can be trained and made sufficiently strong *while in bed* to employ crutches at once on rising. Stay in hospital is thus usefully curtailed.

"Not all the exercises depend, of course, on apparatus ; many patients begin with minimal contractions as they lie flat, passing on through exercises with the weight of the trunk or limb counter-poised so that they can be done without strain ; then finally, the patients reach the stage of increasing their strength and range of movement against the resistance of the springs."

Report B.—"We believe that practically every patient can benefit from some form of these 'spring exercises.' It is not only to the injured limb but also to the sound limbs and the rest of the body that these prophylactic and rehabilitating exercises are applied.

"The idea is to maintain tone and prevent wasting and weakness, so that when the patient can get up he can walk without that weakness previously so common after a stay in bed.

"Recently we had a good example of this in a patient who has been in bed for 17 weeks following an operation to arthrodese his tuberculous hip. The day he was allowed to get out of bed he could walk without any weakness. This we attributed to the spring exercises he had been practising, not only during the daily visit of the exercise team, but by himself in the evenings and other times.

"The springs are left with the patients and they enjoy carrying out these exercises, which they find so much more interesting, so much more *fun*, than just contracting muscles. It also helps their morale by giving the patients an occupation all day (Figs. 169, 170).

"Breathing exercises form part of the routine and we hope so to lower the incidence of post-operative chest complications. One man after an empyema operation so rapidly re-expanded his lung that the empyema cavity was closed in the very short period of four weeks.

"We believe these exercises will reduce the incidence of thrombosis and pulmonary emboli. Our pathologist has shown in the P.M. room how very common are thrombosis and emboli after recumbence in bed. From 10 to 15 per cent. of hospital autopsies showed pulmonary emboli.

"Of course the exercises in each case have to be approved by the

doctor, and we are specially on the lookout to avoid any passive stretching of stiff joints in the orthopædic work. Used scientifically and with common sense we believe these springs and ropes are a most useful addition to any ward in that too often neglected sphere 'The rest of the patient.'"

GRADED EXERCISES FOR THE REHABILITATION OF THE WARDED PATIENT

The exercises have been named and graded A to D; they include breathing exercises and free movement as follows :—

Grade A. "WEIGHTLESS" EXERCISES. (1) Simple suspension.
(2) Oscillatory suspension.

,, *B.* "SUPPORTED TRUNK" EXERCISES.
,, *C.* "TENSING" EXERCISES.
,, *D.* "EUTONIC" SPRING-RESISTANCE EXERCISES.

The principles of treatment underlying such a grading of exercises has been summarized by one of our surgeons at St. Mary's Hospital, London.

The first principle should be the maintenance of function of the whole body *with the exclusion* of the injured area. This is of particular importance for that large range of patients who are confined to bed for long periods while waiting for a local injury to recover.

If this first principle is carried out the damage is isolated, and not allowed to involve other structures from deterioration and disuse. For this a method has been devised by which the whole body can be treated with muscle-toning exercises (Grade D). These exercises are combined with deep breathing. Attention is paid to posture and the maintenance of the circulation, the tone of the postural muscles being the chief concern. General tensing exercises are employed (Grade C), so also are the exercises using a trunk support which will be found specially useful for the treatment of chest and heart cases and for the aged (Grade B).

The second principle is to restore function in the early stages of loss, so that the loss is not progressive but arrested.

Under this heading come two groups of weightless exercises. These only require minimal muscle-work, but they are self-activated (Grade A (1) and A (2)).

The third principle is to attempt to restore function at the stages of late recovery, by varied treatments. For these, resistance units are arranged by which their use is localized to the injury (Grade D).

GRADE A—WEIGHTLESS EXERCISES : (1) SIMPLE SUSPENSION

The weightless exercises have been in use for many years (at St. Mary's Hospital, London), and have been ordered for fracture cases, recent injuries, arthritis and other painful conditions, and for paralysis of both spastic and flaccid types.

Simple suspension exercises are shown in the diagrams ; the slings and ropes are attached to Balkan beams, by means of which the weight of the limb is counterpoised. Movement takes place in the arc of a circle, radiating from the axis of movement. Its character is smooth and level, but can be made pendular by a slight adjustment of the axial fixation.

All types of exercise can be carried out from these fixations, passive or resisted, but, above all, self-activated movement is advocated, for by its means joint mobility and muscle recovery will increase together ; the patient will learn both to relax and control his limb in movement.

If a passive movement is desired for a particular case it will be found that the range of action obtained in a relaxed and carefully suspended limb will be greater than can be obtained otherwise.

For resisted movement, it will be necessary to apply an outside force. This can be done :

(1) By applying manual resistance, concentric and eccentric muscle-work.
(2) By fixed resistance, of pulley and weight, applied so as to work at right-angles to the moving limb.
(3) By variable resistance, using a long spiral spring of suitable strength.

For the warded patient this arrangement of apparatus allows many and varied treatments to be built up which will suit the many different conditions, but here only one standard treatment is given.

Details of Treatment Suitable for the Early After-treatment of a Fracture of the Neck of the Femur fixed with Smith Petersen Pin.

Fig. 162 represents the first exercise which should be attempted, an easy abduction and adduction movement. (The spring which is shown in the illustration is only acting as a compensating device

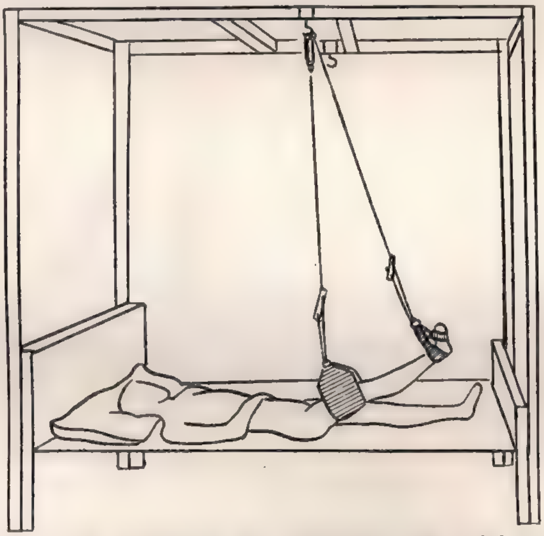


FIG. 162.—Hip abduction and adduction with axial support.

In order to fix the pelvis the exercise is best carried out bilaterally. If this is not possible then the " good " leg is abducted so that the foot rests over the edge of the bed or even so that it rests on the floor. This position will obviate the necessity of strapping down the pelvis.

to take up slack in the upper belt—if this should not fit the thigh properly.) It is as well to demonstrate the required movements on the uninjured limb.

The slings are passed under the popliteal space and the ankle region, or fastened as shown by the foot belt. The ropes are let out, and the slings attached to the clip in the rope. The limb

is then hoisted up a little way, and the patient is allowed to feel that the support is stable, and that he is suffering no pain.

The limb is then elevated to the starting position, and the patient allowed time to feel the sensation of having a limb in suspension before any active work is attempted.

By this means confidence will be established, and the muscles will relax. As soon as this occurs further treatment can be attempted. The slight elevation of the limb shown in the diagram will assist the circulation, and will make a mild treatment in itself.

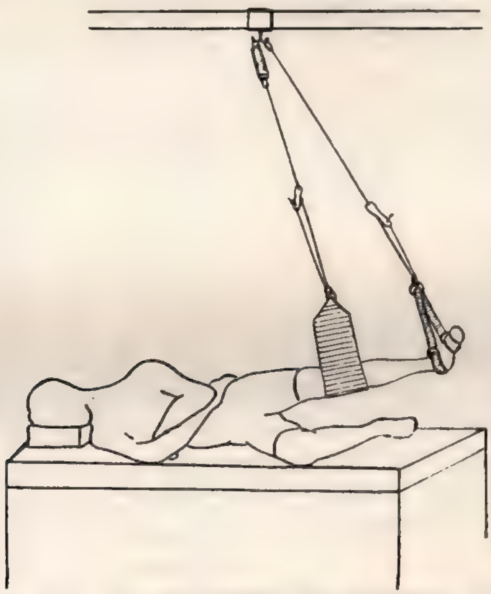


FIG. 163.—Hip flexion and extension.

Note that to fix the pelvis the lower leg should be flexed as near the chest as possible and can be held *by the patient* in this position to obtain accurate movement.

It is necessary to hasten slowly with these cases. Some of the surgeons at St. Mary's Hospital put their patients on to these exercises at a very early period. So far we have noticed nothing but good in the effects. This is doubtless due in some part to the co-operation called for by the method, and the fact that the patient is the working partner.

Fig. 163 shows the patient turned on the side—a few days may have passed before this can be done without fear and discomfort.

Hip flexion and extension will then be carried out, and practised until the range of movement is free.

Breathing is a help with these exercises; movements should be carried out in time to respiration, especially the first few times they are attempted.

Fig. 164 shows how to mobilize the knee joint. This time the exercise *must* be controlled by the operator, and a firm cushion placed between the two thighs. The knee may be stiff and

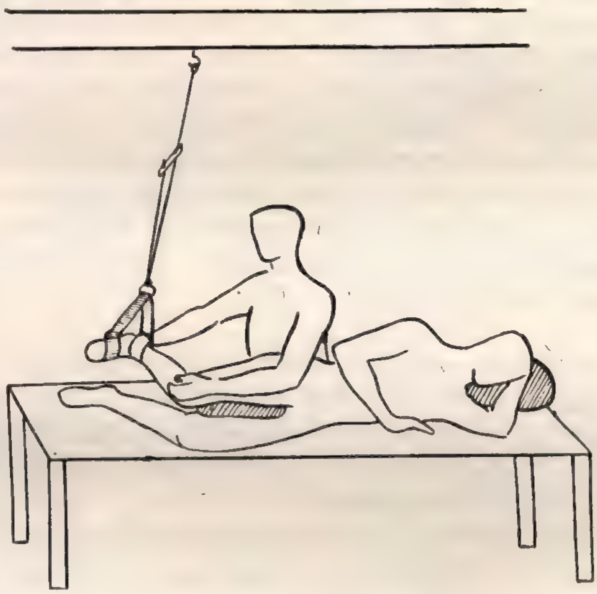


FIG. 164.—Knee extension.

Note the thigh is supported on a hard cushion and the hip is supported by the operator in order to localise the movement to the knee joint.

painful, and the patient will require encouragement to move the joint.

Progressions.—To prepare the patient for resistance work as in Fig. 165, it is best to add some intermediate exercises to teach muscle control, while still keeping up joint movement; for example:

(1) Swinging exercises to the suspended limb, bringing in stop and holding movements at a given time.

(2) Altering the axial fixation so that a " pull back " is felt by the new position of the ropes. Thus mild, but quite definite, resistance can be graded. For the hip joint, the fixation point can be placed first one, then two, foot nearer the patient's ankle. Some resistance will be felt immediately in obtaining the full range of joint movement.

(3) *Posturing.*—By this is meant strong holdings in the extreme positions of the joint, such as flexion, extension or bilateral abduction of the hip joint. The movements must be strongly held and made as purposeful as possible by suggesting the appropriate actions : such as kicking a successful goal for flexion : climbing up a steep hill for extension : " splits " for abduction, and so on. Later, when bilateral spring resistances are arranged so that with the pelvis suspended and the springs placed to resist leg action, " walking can be simulated with alternate movements of hips, knees and ankles. (See p. 283, " Fracture Clinic " and Fig. 279.)

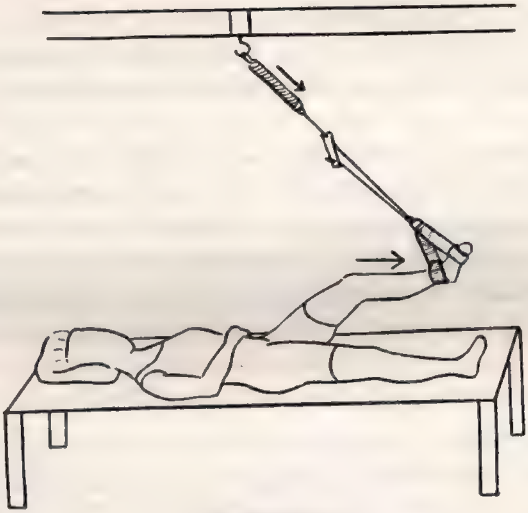
If the patient can visualize what is intended by these movements, a great stimulus to action is achieved. It is here that the personality and understanding of the physiotherapist will be of the greatest value ; apparatus of itself can do nothing, vigour and thought must be put into action.

Precautions.—Throughout all these exercises the greatest care should be taken to isolate the movements, by careful fixing of the pelvis in leg movements ; or by arranging that the limbs are used bilaterally whenever possible.

Fig. 165 shows a new phase of treatment. This is the period when the joints have been fully mobilized, and the muscle tone and bony union have recovered sufficiently to warrant active resisted work ; the patient is no longer nervous, but has full control, though he is not yet fit for weight-bearing.

Resistances can then be set up as stated in the beginning of this chapter. The form of resistance advocated is a good steel spring, for with that, adequate and easily progressed resistance is obtainable. This resistance is bound up " with a challenge to action " and a very helpful recoil. The recoil must be made use of to

double the muscle-work, by bringing in concentric and eccentric effects when the recoil action is controlled. *On no account must a passive recoil be allowed in fracture cases.*



THRUSTING.

FIG. 165.—Hip and knee movement.

Until the patient has mastered the co-ordination of thrust and the controlled return, he should be given only mild resistance. The adjustment is made by lengthening the rope circuit.*

The final stages of treatment will be described under "The Fracture Clinic" as they involve partial weight-bearing and full weight-bearing work.

GRADE A—WEIGHTLESS EXERCISES: (2) OSCILLATORY

These exercises introduce an entirely different series from the above; use is made of the vertical vibratory mechanism of a supported spring, which permits small or large movements without much expenditure of muscular energy. This will enable patients to carry out easy self-activated exercises (Figs. 62–68).

* Four illustrations and part of this article were published in the *Journal of the Chartered Society of Massage and Medical Gymnastics.*

The movement is complementary to the natural pendular movement of a limb suspended on ropes; as against the very slow motions of that lateral pendular movement, these vertical vibrations are rapid.

The patient controls the exercises absolutely. Any initial movements can be carried out by the feeblest person, as very little effort is required, owing to the natural frequency of the spring-system.

Progressive work is evolved by the patient himself in a natural and quite unconscious manner. As he grows stronger he will tend to push against the spring. This will cause the character of the exercises to change, and a mixed movement will result, partly assisted by the kinetic energy stored in the stretched spring, and partly resisted by the force necessary to stretch it.

Finally, the use of this method evokes a sense of exhilaration, which appears to stimulate the patient to further activity.

Group exercises.—If the exercises are conducted with other patients at the same time a spirit of competition is introduced and a cheerful atmosphere is encouraged. The advantage gained by spring suspension has been appreciated by patients who have had the opportunity of trying them, and the results have been extremely satisfactory. The reader is referred to Fig. 65, Chapter X, which represents a particularly useful exercise for the recumbent patient, as the body weight is compensated against gravity by means of the belt and springs placed under the lumbar region. A recumbent patient can reinforce his *movements* by this exercise, which should go far to prevent the danger of hypostatic pneumonia. The energy stored in the springs assists the muscular effort, so that the movements can be repeated frequently.

These oscillatory exercises have been used in the wards of certain London and County Hospitals for the treatment of:

(1) Aged people who have but feeble muscle strength.

(2) Certain Neurological cases where great weakness is the major problem.

(3) Selected chronic Arthritic cases when there is *no danger of stirring up septic foci*, and when joint stiffness is the chief concern.

One such case of chronic arthritis is selected for description to illustrate the method of treatment.

The case of Mrs. X.—This chronic arthritic patient had been in hospital for twenty out of her forty-eight years of life, and was completely crippled in all four limbs, both hands, and the upper part of the spine and neck.

After six months' work so much progress was made that she was able to walk half the length of a ward, raise and straighten the elbows and shoulders, and learned to use her fingers and hands by modelling with plasticine. All improvement in range of joint action once obtained was retained by this patient.

The exercises given included practically all those illustrated in Chapter X, starting with the lumbar spine mobility exercise, as this was the only region of the body where normal movement was obtainable.

Lumbar mobility was therefore practised to a maximum, and it was found that this patient had strong back muscles. Then came the problem of how to get the hip joints to move; they were so stiff that only 2 in. of abduction between the knees could be recorded; also the flexor contracture of both hips was very marked. Oscillatory exercises of the hips were started, and some degree of improvement was registered, especially in the tone of the gluteal muscles. As these muscles got stronger, the flexor contracture became somewhat lessened. Weightless exercises were then substituted, so that the leg was moved on a horizontal instead of on a vertical plane. These movements had to be assisted by the physiotherapist and some forced movements were attempted with traction. The result after six months was an abduction of about 6 to 8 in., measured between the knees (6 in. voluntary movement, 8 in. with help). The patient's upright posture was also improved, the flexion of the knee and hip having straightened out considerably.

Both shoulders and arms were supported on spring suspension at an angle which caused no pain; in this position oscillatory exercises were practised. Every week more abduction was registered, while the muscle tone of the arms improved.

Having mastered the main joints and got them moving on a working plan, these exercises became a routine which the patient

could practise throughout the day, with minor assistance in fixing herself in the correct position.

The treatment of knee and elbow were thought out next. Exercises which involved group actions of joints were found to be more satisfactory than special individual joint actions. For instance, a simple arm extension exercise with pulley-and-rope fixed to an overhead beam was more fruitful in its effect for extension of the moving elbow, and wrist and for inducing the patient to use the hands, than was obtained by a more localized movement, such as flexion of the elbow, wrist or fingers.

It would appear from experience with these cases, that *the actions of thrust and stretch are of primary importance*, and that individual joint movements should be the finishing, rather than the commencing exercises for such treatments. To obtain perfection of movement, individual joint work is, of course, absolutely necessary, and will follow upon the group actions ; for instance, weightless exercise or simple Swedish remedial exercises in flexion and extension of elbow and wrist.

As one of the aims of this book is to stimulate interest in the helpless patient or in those who, from one cause or another, are doomed to spend long periods of time in hospital, it is suggested that much could be done to make them more independent. If all hospital beds were equipped with simple devices, these persons could move by themselves, even though it may only be within the confines of their beds. A wooden foot-rest, preferably covered with sorbo-rubber, which has such an excellent give-and-take texture, would make an admirable beginning, as it would encourage toe movements and a consequent increase of tone and circulation in the lower extremity (see Appendix 7). (In default of rubber, short compression springs, such as are used in chair upholstery, would, if properly arranged, have much the same effect.)

If every bed could be equipped, like a surgical bed with that useful upright known as the " Pearson pulley," or " lifting pole " it would be most helpful. This device allows each patient more liberty, and enables him to assist the nursing staff on many occasions when weight-lifting is required. These occasional movements could be supplemented by the physiotherapist to some remedial end ; thus the patient's energy would be constantly

revived and not allowed to ooze away from sheer lack of opportunity. To this upright fixture resistance-springs or pulleys can be attached, and a great variety of exercises are immediately available.

Patients who " enjoy " bad health, or are resigned to it to such a degree that they will no longer face the world, had better be left alone ; but there are many others who will take the opportunity of self-activity that is offered.

The time spent on such work is worth while, and should be developed, so that in our new and reconstructed England we shall have no " Cripple hospitals " and no wards segregated to the " hopeless " cases, who are just left alone as far as actual remedial treatment is concerned.

If such measures were carried out on a large scale the financial saving to the country would more than compensate for the expense involved in salaries, and the simple and inexpensive equipment which is necessary to encourage self-activated movement. The problem of home life or lack of a home must not be forgotten. Some of these poor souls *dare not* get better ; they have nowhere to go. They look upon the hospital as their permanent and final home.

From the point of view of national economy this is wasteful ; alternative accommodation—but not necessarily of the expensive hospital type—must be forthcoming in the scheme of things to come.

GRADE B—TRUNK-SUPPORTED EXERCISES

These trunk (Grade B) exercises have been used in the treatment of heart and lung conditions because they promote early rehabilitation of the whole body. (Figs. 167 and 167A.) The gentle trunk movements aid the function of the abdominal organs, assisting in particular the portal and respiratory systems. These exercises are much liked by the *aged patient.*

The characteristic of these Grade B exercises is their rhythm and smoothness of action. Progressions are made by increasing *the number* of times each exercise is carried out, leaving it to the patient to increase automatically the *power* put into the actual performance as he feels stronger.

Fatigue in carrying out these trunk movements is much less than might be expected, as the work of the " holding " muscles is cut out by the use of the support, therefore the patient's energy is expended almost exclusively on the remedial movement prescribed. The patient can rest between the exercises by relaxing against the support, and the deep breathing exercises have a refreshing effect.

As the exercises are carried out in an upright sitting position, the patient obtains a clear sense of movement. Balance is practised, so that, later on, risks of a possible fall from giddiness will be obviated.

A warded patient as a rule has to sit up in bed many times during the day ; it is an excellent drainage position, but is apt to be very fatiguing, owing to weakness of muscle and the stretching of the posterior ligaments of the back and legs.

The belt support will serve two purposes : it will support the patient's back at a steeper angle than is possible with pillows, and at the same time the belt becomes the medium through which active exercises of a gentle rhythmic character can be carried out for the muscles of the trunk.

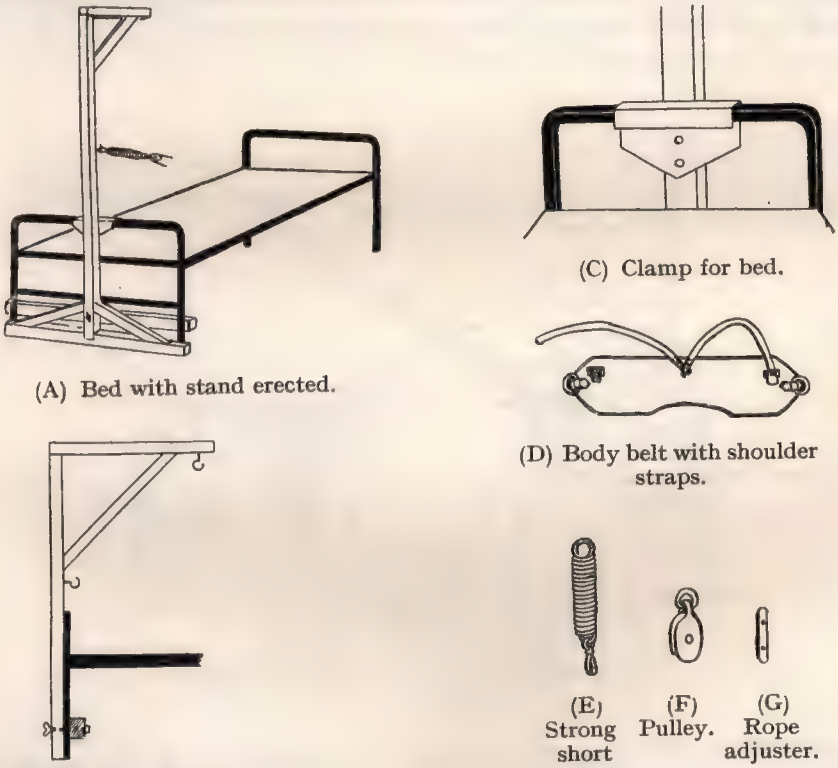
The essential apparatus is a combination of pulley and spring systems, and consists of:

(1) A supporting belt of strong canvas with shoulder straps.
(2) 3¼ yards of rope attached to a pulley with adjusting device.
(3) A strong spring, tension type, 7 in. long by 1¼ in., made of thick wire. This spring is designed to limit movement to small ranges, and to give a feeling of *stability rather than mobility* to the convalescent patient.
(4) A foot rest.

The whole little outfit is supported from the curved bar and chain found on fracture beds. The only alteration required is that the patient must face the bar. Usually the bed will have to be reversed.

While the trunk exercises are being performed the patient must place his feet firmly against the foot-rest to obtain a counter-thrust with the legs. The leg muscles are thus brought into full, though unconscious use. This thrusting action will establish the sensory

reflexes of contact through the feet, and be of assistance when walking is attempted. Another effect will be produced which is of value, and that is the straightening of the knee joints by active muscle-work, thus counteracting the flexion contracture which tends to occur when pillows are placed under the knees of bed patients for long periods.



(A) Bed with stand erected.

(B) Side view of stand.

(C) Clamp for bed.

(D) Body belt with shoulder straps.

(E) Strong short spring. (F) Pulley. (G) Rope adjuster.

Fig. 166, A to G.—A portable stand and gear for bed exercises for the convalescent.*

For emergency medical services' medical beds a separate stand has to be supplied, which must be an independent unit (see Fig. 166).

For group treatments.—Several independent stands are very useful to carry from bed to bed.

By means of this apparatus patients can carry out *gentle active exercises of all the abdominal and back muscles.*

* See also Appendix 1 for a modern type of apparatus called the "Bed Gym."

Back extension is performed against resistance, with inspiration on the backward movement and expiration on relaxation.

It is interesting to note that " the descent of the diaphragm is favoured when the patient is in a vertical position rather than in a recumbent position, as gravity will assist the action ; but when lying on the back the liver is pushed in an upward direction (not downwards) and the easy descent of the diaphragm is impeded ; this is one of the reasons why people with heart or lung diseases

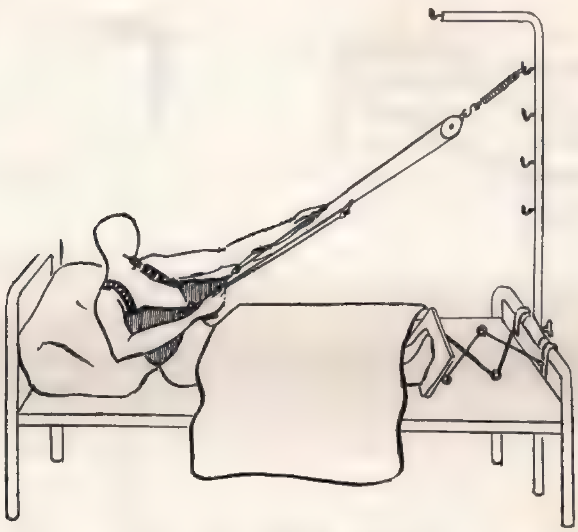


FIG. 167.—Trunk rotation.

Note the pulley allows the rotation movement.

usually prefer to sit up rather than lie down." (R. Hutchinson's *Applied Physiology*.)

Trunk extension.—Weak patients should at first hold the rope, and pull back against the resistance of the spring, counter-thrusting with the feet against the foot-rest. To progress, the patient can place the hands on the hips, or take neck-rest position. This will involve raising the centre of gravity and brings in the element of balance.

Movement occurs in the hip joint and vertebral column. The muscles involved are the hip extensors, erector spinæ and the

back muscles. Inspiration takes place with back extension; expiration and relaxation on the reverse movement.

Trunk flexion.—The abdominal muscles are brought into play by flexing the trunk and "pulling in" the abdominal wall, particularly at the lower one-third. To assist the movement, the arms may be used to pull on the rope and spring, and an audible expiratory respiration is made in this position. In this way a good contraction can be obtained of the abdominal muscles in their inner range, and the respiratory movements are greatly

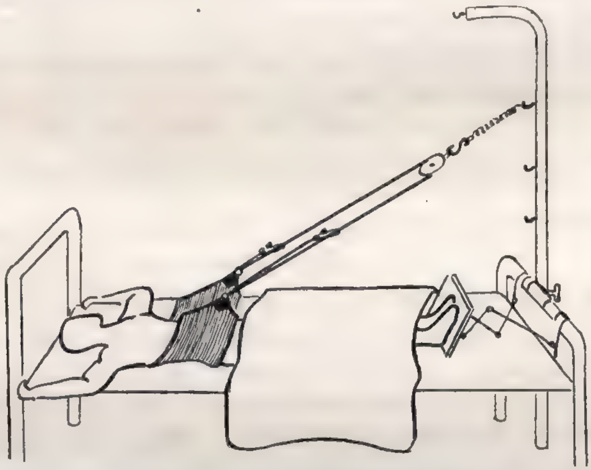


FIG. 167A.—Trunk backward arching to restore the lumbar curve and to reduce backache.

assisted. The patient then relaxes back on to the belt, and breathes in.

Trunk side flexion.—The patient bends sharply over the operator's hand, which is held in support.

Movement occurs in the joints of the vertebral column and in the thorax. Muscle-work is for the side flexor muscles of the trunk. (Deep breathing and relaxation, as before.) The stomach and liver are alternately compressed.

Trunk rotation (Fig. 167).—The patient holds the rope (or hips firm or neck-rest for progression) and turns his trunk in full ranges of movement from right to left, and back again, keeping the head in the mid-line of the body.

Movement occurs in the vertebral column. Working muscles are both anterior and posterior trunk rotators, those muscles which are placed obliquely on the body, and which work in opposite pairs.

Trunk back arching.—The belt is slipped down to the waist line, and the ropes are lengthened so that the patient can *arch the lumbar spine* against the pressure of the strong spring ; the head should touch the pillow. This last exercise gives great relief if there is backache, and restores the normal lumbar curve, which often is dangerously obliterated in cases of prolonged bed-lying.

Movement occurs in the hip joints and vertebral column. Muscles worked are chiefly erector spinæ, gluteus maximus and the posterior lumbar muscles.

GRADE C—TENSING EXERCISES

General Exercise by Static Contractions, Tensings, and Holdings

(1) **Static contractions** involve no joint movement. Such contractions are obtained by faradic current and by voluntary power. In the latter case the patient isolates individual muscles or groups of muscles by *thought process*. The contraction involved will be a lifting action from the bone. These movements—even if no joint is moved—have an exact physiological value as regards innervation, circulation and the maintenance of tissue-tone.

(2) **Tensings.**—In muscle-tensing the working muscle is shortened and broadened ; its blood supply is reinforced and its nerves put into conscious action—a joint is moved.

(3) **Holdings.**—Holdings follow tensings, for periods determined by counting, and are followed by complete relaxation.

All these forms of activity are usefully employed for warded patients. In case (1) muscle strength can be kept up by will-power, or if a limb is immobilized in plaster, static muscle-work must be employed until the muscle development is such that the plaster itself can be used as a resistance.

In case (2) a joint movement takes place. If the range of movement is full, and followed by a " holding," a very satisfactory type of exercise is achieved.

For general exercise.—The whole body can be brought into activity, region by region, with a great variation of muscle-work, using partly tensing and partly static contractions in alternate or synchronized actions. Progressions are made by timing; the exercises can be taken slowly, quickly or to music.

The back muscles (transverse or longitudinal) are used to alternately stretch and hyperextend the spine from pelvis to head. Finally, the abdominal muscles must be contracted and retracted. All these exercises are interspersed with breathing exercises.

There are always a number of patients, especially old women, who find great difficulty in performing this type of muscle-work. They are not in the least interested in the culture of their bodies, nor sufficiently intelligent to understand the necessity to concentrate on any exercises they are asked to do. They have no "muscle sense," and therefore it is better for them to try out exercises where *normal* active movement takes place (such as Grades B and D). Otherwise a great deal of time may be wasted on the part of the physiotherapist.

GRADE D—FURTHER "EUTONIC" EXERCISES

Case of bilateral hernia.—Fig. 168 shows a patient aged 46 a few days after an operation for long standing bilateral hernia.

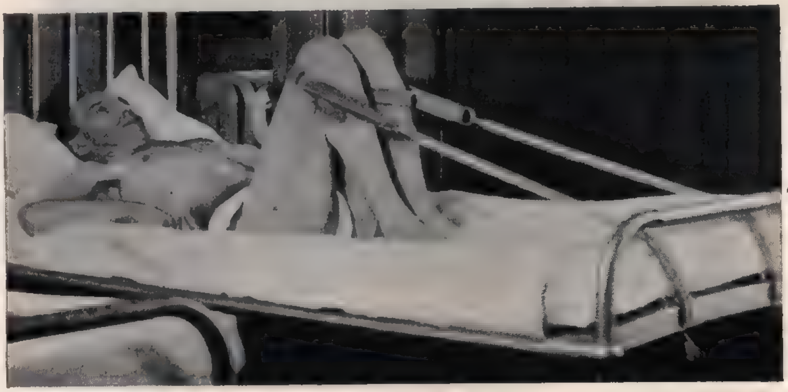


Fig. 168.—Eutonic abdominal exercise used for a case of bilateral hernia after operation.

At Hammersmith Hospital, by kind permission of the Chief Medical Officer of the London County Council.

The aim of the treatment is to strengthen the abdominal wall, especially the lower area, while the patient is still confined to his bed.

By working the hip joint muscles against carefully arranged spring-resistances the following effects can be obtained.

1. Single or double hip flexion will obtain associated effects on the straight abdominal fibres.

2. Double hip side flexion and pelvic rotation will obtain associated work of the abdominal oblique fibres.

FIG. 169.—The " crutch walk." (Position 1.)

A strong co-ordination exercise to be practised in bed.

3. Single hip abduction in the crook position will obtain associated action of the lateral abdominal fibres.

For exercises 2 and 3 the springs are crossed and can be attached

to the wire mattress of the bed with an ordinary (meat) hook. The other end of the spring is attached to the patient's knees by the self-adjusting strap illustrated in Fig. 7, B[1].

The "Crutch Walk" (using elbow crutches)

To walk with one leg, using elbow crutches, patients require very strong extensor muscles of the arm and elbow, also strong

Fig. 170.—The "crutch walk." (Position 2.)

Vigorous exercise for the anti-gravity muscles.

adductor shoulder muscles to keep the crutches near the body. The hand grip must be developed so that there may be no fatigue from prolonged manipulation of the crutches. Patients have been

known to fall and have serious accidents through no other fault than poor muscle tone.

If the elbows fly out, owing to the weakness of the extensors, the patient must fall. This need never happen if a little intelligent anticipation is used and these muscles are selected for intensive training before allowing the patient out of bed.

Some few days before taking to crutches the unilateral eutonic exercises (Figs. 72–77) should be changed to a co-ordinated type involving both arms and the uninjured leg. While extension and adduction movements of the arms are carried out against spring resistance, the "good" leg is co-ordinated, and timed to work with the arms. The leg carries out a strong thrusting action, involving back and hip extensors and the knee must be pushed out quite straight. The patient should lie as flat as possible so as to use the back muscles and practise good posture. Figs. 169 and 170 illustrate these points and the general arrangement of the resistance springs.

Contracture of Hip and Knee as a Result of Bombing Injuries

Case of X1, Emergency Medical Service Hospital, Amersham, Bucks. Age 61. Victim of oil bomb explosion, October, 1940. Transferred to country hospital, from a London hospital in December, 1940. Surgeons: V. Snell, F.R.C.S.; R. King, F.R.C.S.

Injuries, multiple.—*Right leg* blown off 8 in. from the groin by the bomb explosion.

Fingers and hands badly burnt; the thumbs escaped.

Back.—Very extensive burns all over the back which caused intense pain, so that any rest position was most difficult to obtain.

Right shoulder also suffered severe injury (supraspinatus-strain); so the man was unable to support himself by his elbow on the right side. As his right leg was also missing all supporting and balancing work had to fall on the left hand and left leg.

(Fig. 171.) *Left leg.*—Severe "postural" contraction of left hip and knee, joint in 38 per cent. flexion. The patient was gravely shocked, very weak, and not expected to live. Two blood transfusions were given in December. Owing to intense pain, due to burns, loss of the right leg and injury to the right shoulder, he was unable to balance or shift his position in bed. To compensate for this he contracted the *left* leg, probably unconsciously, until he acquired a fixed postural deformity of 38 degrees in flexion. At rest the leg was adducted, so that the knee joint lay across the chest, against the *right* shoulder ! The flexed leg made it impossible for the prone position to be used as a relief from pressure on the burns of the back. It was in this condition that he was found on arrival at the hospital in the country.

Multiple injuries require multiple treatments, so this rigid contracture, which was only one of his troubles, would probably have been left, until such time as the patient's condition allowed of further surgical manipulation, or of correction by plaster and wedges. However, to interest and occupy the man, rehabilitation exercises, *e.g.* eutonic resistance exercises, were suggested, and after a time carried out by the patient himself, under the constant supervision and encouragement of the physiotherapist in attendance. General activity was visualized rather than curative action for the severe contracture, but the final result was most satisfactory. The contracture was entirely overcome, the morale of the patient was wonderfully improved by his own active efforts, and the tone of the anti-gravity muscles was gradually restored.

Progress was so gradual as to be imperceptible, but records and photographs were able to show the improvement due to this self-activated method of treatment.

TECHNIQUE AND APPARATUS USED FOR THIS CASE OF KNEE CONTRACTURE.—A long supple helical spring was inserted into a rope-and-sling outfit. A fixed point was obtained from the fracture-bed overhead arm, and later from an overhead Balkan beam.

(Fig. 171.) The first fixed point for the support was placed over the centre of his body. A bent rigid leg is really equivalent to a bent lever, therefore the weight-arm of the lever in this case

extended from the hip joint or fulcrum to the sole of the foot. The man's foot was placed in the sling and the ropes adjusted *so that the spastic flexors were supported in flexion,* the whole leg being balanced by spring suspension.

He was then encouraged to press and thrust his leg down towards the bed, using gluteus maximus to extend the hip ; this movement was resisted by the spring, which in turn became elongated. The moment the extension movement ceased, the kinetic energy of the spring came into action, and returned the

FIG. 171.—A case of severe postural contraction.

leg to the starting position by its recoil. This caused a slight *stretch reflex to be set up in the gluteus maximus and the impulse to contract the muscle again, was stimulated.* These continual and repeated movements of stretch and thrust of the hip extensors tended to push on the knee-joint flexors, and the knee-joint contracture gradually gave way and began to straighten.

At first the patient was so weak and ill that it was only possible to attempt a very few movements, but his interest was aroused and he became daily more and more persistent in his efforts, until

he was able to carry on with this exercise literally hundreds of times throughout the day.

As the locked knee gave way and straightened out the quadriceps gradually came into play. The fixed point of suspension was then altered so that the weight arm of quadriceps was " balanced out " by the spring, and alternate stretch-and-thrust actions set going in this muscle. The weak quadriceps was soon able to work with more vigour ; a 4-lb. weight was later added to assist the straightening process (Fig. 172).

FIG. 173.

FIG. 172.—After a course of eutonic exercises.
FIG. 173 (Inset photograph).—Patient up and about.

This man worked hard, but it took five months to straighten that knee ! The time was " saved," in that during a convalescent period necessary for the healing of all his wounds and burns the knee was gradually straightened. He realized that if he could straighten the knee himself he would save further surgical interference. The illustrations show the position of the knee in January and June, 1941. Inset is a small snapshot of the patient (July, 1941) walking on crutches, his nerve restored and his

pleasure at having overcome his own disability was good to see (Fig. 173).

On working out the various points of suspension (Fig. 174) it became evident that certain principles of treatment had been carried out.

(1) The spastic flexor muscles were relaxed and supported.
(2) The stretch reflex—a primary reflex, automatic in action, was constantly brought into action. In a case such as this, it is better to initiate extension of the whole leg by mechanically stretching the quadriceps (by means of

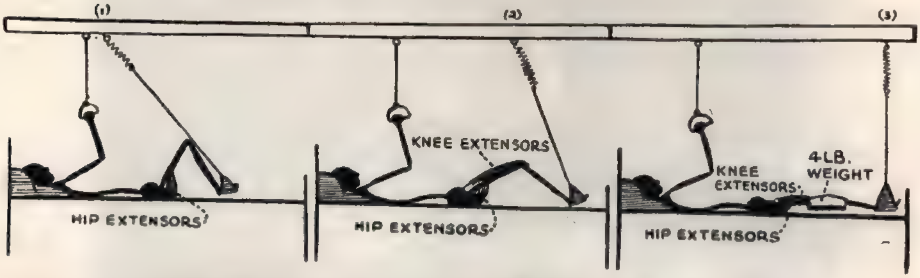


FIG. 174.—Key diagram to show how the suspension point effects muscle action.

natural hip extension) than by any direct attack on the knee joint itself.
(3) The "weight arm" of the selected working muscles was "balanced out" so that the weakened muscles had a better chance to act.
(4) Self-activity by the patient induced restoration of morale and caused a renewed interest in life.

Re-education of the stump.—It was necessary to re-educate the man's stump; and the springs were again used to good effect for the muscular development of the 8-in. stump of the right leg. As the condition of this patient was so feeble the treatment had to start while he was still confined to bed.

A Practical Rehabilitation Treatment for the Re-education of the Stump after an Amputation of the Femur.

An amputee can be trained while still in bed to harden the stump, and to exercise the extensor and adductor muscles of the hip joint, if resistance apparatus is available with which he can practise several times a day. If the tone of the gluteus maximus is not quickly preserved, then nothing can stop flexion deformity, for the ilio-psoas group will take charge, and the greatest trouble will be experienced in overcoming the contracture which then follows. Strong adductors are also very essential muscles when the time comes for fitting the artificial leg, and when trying to walk. For these reasons, and because of the extreme simplicity of the necessary fixations for exercise, spring resistance exercises with a "eutonic-unit" are advocated. By means of this method the resistance can be progressed continuously by using stronger springs, and the patient can carry out exercises throughout the day.

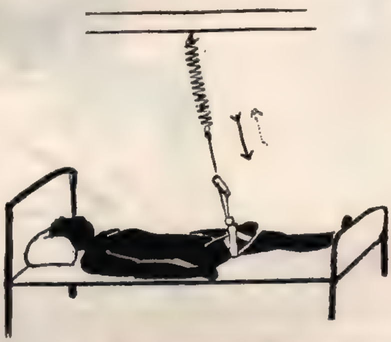


Fig. 175.—Suspension and extension.

At first the stump is suspended from an overhead beam, from a fixation slightly behind the hip joint (Fig. 175). The best sling for the purposes of this treatment should be a long narrow one. It should be passed figure-of-eight fashion round the stump to support it, and at the same time exert a pressure from below upwards, in order to assist the contraction of the loose and tender tissues. The sling is then clipped to the eutonic-unit—rope and 15-lb. spring—and counter-balanced against gravity.

At first the physiotherapist should remain with a new patient to *assist* the movements, by giving first an upward flexion, in order to put the gluteus maximus on the stretch; then to assist the movement in the direction of extension. These movements should be repeated for or with the patient. In this way a "*stretch-reflex*" *stimulation* is given to the weakened extensors, while the tightened flexors are reciprocally relaxed.

After a while the patient may be able to pick up the rhythm of the movement and continue the reflex-stretch with the aid of the spring's rapid recoil, and be able to exert unaided sufficient force, but with gravity in his favour, to work against the mild resistance of the spring. As the patient progresses, the spring must be changed for a stronger one (20, 30, 40-lb. spring) until a really satisfactory extension strength is obtained.

The adductor muscles.—As the adductor muscles are damaged by the amputation they will be very weak, and will require most careful training; first by static exercises to acquire control, and then by the application of appropriate resistances applied manually

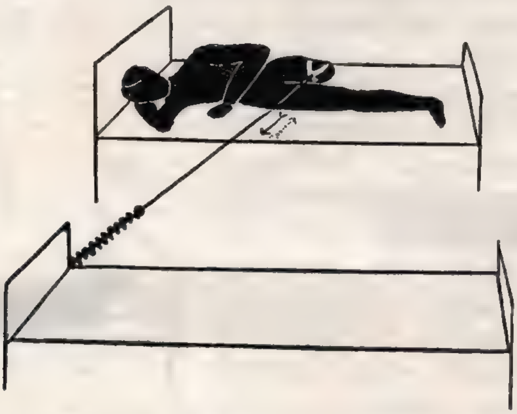


FIG. 176.—Extension and abduction.

and later with apparatus. The limb is first suspended to be free from obstructions, and then exercised against the vertical resistance fastened to the overhead bar so that the adductor muscles can be specially exercised, but the patient's position is side lying (Fig. 175).

Side-lying (Fig. 176).—If the patient can now *extend and abduct* the stump the same attachment of sling and eutonic unit can be fixed on to an adjacent bedstead at such an angle that the oblique pull will not dislodge the figure-of-eight sling.

Alternatively a weight-and-pulley device will be just as good, if not better, as the resistance can be more minutely graded and measured; but on the other hand the fixations required for

pulley-and-weight are more difficult to arrange, and involve more trouble than merely clipping a spring on to an adjacent bed.

Patient out of bed (Fig. 177).—A high-ride plinth makes a good seat for the patient, and one which will give stability to the other leg and the arms, while the stump hangs at the side. With pulley-and-weight resistance the extensor muscles are exercised, but now the *range* of movement can be extended to a maximum and the testing of muscle strength continually recorded.

As a variation the eutonic-unit can be fastened to a wall-bar at a slightly higher plane than the stump, so as not to displace the fixing sling; with this a variable resistance can be set up for further muscular development.

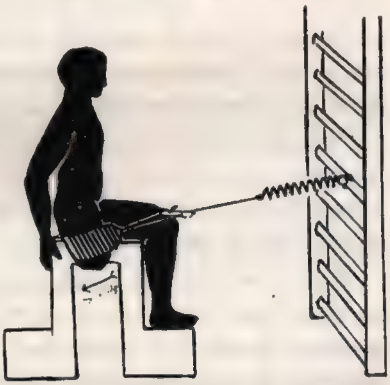


Fig. 177.—Extension and adduction.

In this way spring suspension, spring resistances, weight-and-pulley devices all take their logical part in self-activated exercises of a rehabilitating character.

Patients can be assisted by heat therapy, and contrast baths, with a view to improving the circulation of the stump before the administration of rehabilitation exercises.

Massage.—Massage is no longer given or advocated by the surgeons at Queen Mary's Hospital, Roehampton, as it is said to promote the symptoms of the phantom limb. The treatments advised by George Perkins, F.R.C.S., and R. D. Langdale Kelham, M.R.C.S., L.R.C.P., are a special form of tight bandaging to induce a conical stump; weight-and-pulley exercises to produce strong muscles, chiefly glutei and adductors; and re-education of walking with the artificial limb.

Chapter XIII

RECOVERY AFTER FRACTURED FEMUR

The personal experience of a surgeon and patient.

Eutonic Exercises in Practice

By Lt.-Col. A. J. Cokkinis, F.R.C.S. R.A.M.C.,
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Apart from fractures of the skull and spine, and perhaps of the chest and pelvis, no fracture in the body leads to so much loss of life or disablement as does fracture of the femur. Moreover, while the other fractures just mentioned are serious, only because damage has been sustained by such organs as the brain, spinal cord, lung, or bladder, in the case of the femur it is the fracture itself which leads to serious consequences.

The prevention and treatment of these consequences is very largely the concern of the physiotherapist, and for this reason a careful study of what may happen after a fracture of the femur, and of how untoward effects may be avoided or removed, is a necessary part of the training of every student of physiotherapy.

In most ways the least serious fractures of the femur are those which involve its *lower end*. Near the knee the bone is fairly superficial and a good reduction is often obtained without much difficulty. Constitutional effects are not severe, while the fracture unites soundly and fairly rapidly in most cases. Perhaps the worst danger is implication of the knee itself, with subsequent arthritis and stiffness of the joint.

Fractures of the *neck of the bone* are serious, for several reasons. The patients are often elderly and prolonged immobilization in bed is fraught with danger. Pulmonary complications and severe debility are liable to occur and may lead to a fatal outcome. But though most cases recover, fixation of the fragments is notoriously difficult. There is thus a great tendency to non-union of the fracture, and this may lead to so much disablement, that the patient's life is scarcely worth living. Added to these, there is considerable danger of necrosis of the head of the femur, which

increases the chance of non-union and may lead to a very crippling form of osteo-arthritis of the hip joint.

In recent years a method of treatment has been introduced which has diminished all these dangers. Neck of the femur fractures can now be firmly fixed with a three-flanged nail by a simple and safe operation (Smith Petersen nailing). A long stay in bed or plaster becomes unnecessary, the patient can move the limb freely from the start, and lung complications or serious debility are made unlikely. Moreover, because of the firm fixation of the fragments, the fracture usually unites in a reasonable period. It may safely be said that this nailing operation is one of the very greatest surgical advances of this century.

Fractures of the *shaft*, are in some respects even more serious than those of the neck. Operations for immediate fixation are not satisfactory, and it is still necessary to use prolonged traction in bed to correct the gross displacement usual in these fractures. Although union commonly occurs in eight to twelve weeks, final results are often poor. There may be unsightly and often crippling shortening or angulation of the bone; or the position may be good, but the limb may be left weak, stiff, and painful, because the muscles have wasted and become stuck to the bone, or because adhesions and contractures have occurred in the knee capsule. Except in young people it is not unusual for two years or more to pass before the patient recovers anything like normal function, and many are left crippled for life.

No fracture illustrates better the crucial difficulty in the treatment of all fractures of the shafts of long bones—how to obtain sound union of the bone in good position, and, at the same time, maintain undiminished the freedom of movement and functional efficiency of the limb. Gross displacement obviously must be corrected and *the fractured bone must be immobilized for a sufficient period to ensure union*, if the limb is to function as an equal partner of its uninjured fellow. The wrong kind of physiotherapy might easily interfere with union or even cause redisplacement of the fragments. But what is the use of a perfect anatomical femur if the knee joint loses its range of movement, and the thigh muscles become fixed to the bone and wither to nothing, through prolonged fixation and disuse?

Some form of compromise is therefore necessary which will give enough fixation of the fracture to ensure union in good position, and, at the same time, *reduce to a minimum the loss of joint movement and muscle function* produced by prolonged immobilization. Provided this loss of functional efficiency of the limb *is* kept to a minimum, a large part, if not all of it, may be restored after union has occurred.

It is all a question of intelligent and well-timed physiotherapy. Other things being equal, the younger the patient the better will be the result. But even with middle-aged or elderly people a very good end-result can be obtained by a combination of good surgery and first-class physiotherapy.

What good physiotherapy can do in even the worst cases nobody knows better than the writer, who, eighteen months ago, had the misfortune to fracture the neck of his left femur two days after getting up (on crutches) from a fracture of the shaft of the same bone. Added to the wasting and stiffness following three months of skeletal traction in a Thomas splint came the disturbance of a nailing operation and a further two months in a plaster hip spica (because of the fragile state of the bone). Such a combination in a patient well past his youth might easily have led to permanent invalidism ; but, thanks to two saving factors, a year after the second fracture the writer succeeded in getting an A category at an Army Medical Board.

These two factors were *determination* and *good physiotherapy.* There can be little doubt that this kind of personal experience teaches something which no amount of treatment of others can do, and it is this knowledge that is here offered to the physiotherapists of the future, in the hope that it will add to the skill which is, and will be, so sorely needed in this war-torn world.

DETAILS OF PHYSIOTHERAPY

RECUMBENT STAGE

Fractures of the Shaft

These are dealt with first as they set by far the more difficult problem to the physiotherapist. We will assume that the patient

is in bed, with the fractured limb supported in a skeleton splint, and with skin or skeletal traction (wire through tubercle of tibia) and counter-traction provided.

It will be seen that the physiotherapy is almost entirely a matter of *exercises*, and that massage, faradism, and other physiotherapeutic measures are of very secondary value. The exercises are classified into three groups, according to the period of the fracture.

FIRST PERIOD: *one to eight days*.—" Watch the lungs and circulation."

The *object* of exercises in this period is to *guard against a fatal result* by preventing pulmonary collapse, broncho-pneumonia, and pulmonary embolism (by blood-clot or fat). The last is a very real danger, and the writer has seen two fatal cases in the same ward within a month, both femur fractures in rather elderly women. These dangers can be prevented with certainty only by maintaining the maximum muscular activity possible, with the object of fully ventilating the lungs and keeping the circulation on the move. These aims are so important that it may be wise even to run the risk of producing slight strain at the fracture-site. In the early part of the first week, at any rate, such strain will in no way imperil the union of the fracture.

EXERCISES

(1) *Breathing exercises*.—These are the most important. The lungs should be fully ventilated every hour (but the patient must not be wakened from sleep). *Regional lung exercises* are of the greatest value when supervised by an expert physiotherapist. They are divided into: (*a*) Diaphragmatic; (*b*) Intercostal (one side at a time); (*c*) Basal (to expand the lung bases). These breathing exercises are particularly necessary, as it is usually impossible to sit the patient up without interfering with the effectiveness of the weight traction.

(2) *Trunk and limb movements*.—Every possible *active* movement of the trunk, upper limbs, and the intact lower limb should be carried out at regular intervals, to keep the circulation moving, to preserve muscular fitness, and to maintain a cheerful and active mental outlook.

Such movements are allowed as, full circumduction of the arms

combined with deep breathing, hyperextension of the shoulders, full movements of the head and neck, limited trunk bending and turning, and all movements of the intact lower limb which do not cause undue strain at the fracture site (as shown by local pain). In the fractured limb, only toe exercises are allowed, but they must be full ones.

SECOND PERIOD: *second and third weeks.*—" Do not strain the callus."

Objects.—This is the most vital period of callus formation, as it is during these two weeks that most of the scaffolding on which the fracture is to be repaired is laid down. Any strain or stress at the fracture site, and above all any movement there, may seriously interfere with repair, or cause actual non-union. Therefore no exercise is permitted which is at all likely to cause such strain or stress.

This means that only a few active movements are permissible in the fractured limb. The only safe exercises are free movements of the toes, and of the mid-tarsal and subastragaloid joints. Active movements of the ankle are allowed only through a short range, as full plantar and dorsi-flexion exercises involve contraction of the thigh muscles and so may strain the fracture. Full *passive* movements of the ankle, however, are helpful at this stage.

Above all, *no voluntary attempt should be made to contract the quadriceps or any other thigh muscles during this period.* In the first six weeks or so these muscles (especially the iliopsoas and adductors) frequently go into spasms. Such spasms are very unpleasant, and, in addition, they may pull the fragments out of alignment and delay union. Adequate weight traction controls these involuntary contractions to a large extent, but does not completely prevent them. But the writer found that very gentle friction massage, coupled with mental suggestion, very often succeeded in relaxing the spastic muscles. After a little training he was able to obtain full muscular relaxation, with considerable benefit both to himself and to the fracture.

Tonic contractions of the opposite quadriceps should also be avoided at this stage, as they are apt to produce sympathetic contraction of the quadriceps on the fractured side. Also all exercises involving a strong pull on the pelvis are to be avoided.

Permissible Exercises

(1) In the fractured lower limb only the toe and foot exercises mentioned above.

(2) In the intact lower limb free active toe, foot, and ankle exercises are allowed, but no active movements of the knee or hip. Passive movements of these two joints, however, are both safe and very helpful.

(3) Breathing exercises, head and all upper limb and shoulder-girdle exercises, with and without sling-suspension (see later), are most beneficial. Movements of the spine should be limited to the cervical and upper dorsal regions.

Third Period : *fourth week onward.*—" Re-educate the muscles with eutonic exercises." It was during this period in my own case that I suggested the word " eutonic " to the author of this book, so as to give a general name to all exercises which aim at restoring muscle tone and activity.

Objects.—(1) To restore full muscular tone and efficiency of the whole body, but particularly of the intact lower limb, which will have to do double duty at the start of the ambulatory period.

(2) To re-educate and re-develop the muscles of the fractured limb, at first by contractions without movement, and later, after traction is discontinued, by movements in this order : assisted, unassisted, and resisted.

Exercises

(1) *On fractured limb.*—Muscular contractions without movement, or " tensing exercises," are of the greatest possible value once the callus is firm enough to resist muscular action. After fracture of the femur these tensing exercises can be started safely early in the fourth week, but not before. The contractions should be taught in the following order :

(*a*) *Segmental : e.g.* tensing of all thigh or all leg muscles at the same time (voluntary).

(*b*) *Group : e.g.* tensing the quadriceps—the most important of all these tensing exercises—the calf muscles or the peronei (voluntary).

(c) *Individual muscles:* such muscles as the tibialis anticus or peroneus brevis can be contracted individually by intelligent and co-operative patients, but faradic stimulation will be found extremely helpful in this connection. Faradism can also be used to produce contractions of the separate parts of the quadriceps, a useful exercise but beyond the patient's own will power.

These tensing exercises are carried out while the knee is immobilized by weight-traction. The ankle, however, is not immobilized, and full active movements of this joint are now commenced, at first unresisted and later against manual resistance by the physiotherapist. Flexion of the toes of both feet, against resistance, is an extremely valuable exercise, as it prevents collapse of the transverse metatarsal arch, a common and disabling complication.

By about the tenth week the shaft has usually consolidated enough to allow safe removal of the traction appliance. The patient should stay in bed for another two weeks, and in this period massage of the thigh, hip, and leg muscles has a useful place. At the same time movements of the hip and knee are commenced. At first these movements must be gentle and assisted by the physiotherapist, to avoid all strain on the callus. For the actual exercises and the assistance apparatus to be employed the reader is referred to other parts of this book under "Weightless Exercises," Grade A (1), Chapter XII.

(2) *Other lower limb.*—Tensing exercises are practised as in the fractured limb; these may be done symmetrically as well as separately. Active movements of all the joints are now carried out in all axes and directions, against gradually increasing resistance. Full resistance is not to be employed until after the sixth to the eighth week, according to the X-ray evidence of union.

The resistance may be supplied by the physiotherapist, by gravity, by the patient himself, or by the slings and springs so well described and illustrated in Chapters X and XI.

(3) *Trunk and upper limbs.*—All possible exercises against resistance are carried out at least twice daily. But no movement producing a strong pull on such pelvic muscles as the glutei, or ilio-psoas, should be allowed before the sixth to the eighth week.

Resistance Exercises with Slings and Springs

The writer found great benefit from the use of the long and short eutonic-units, against the resistance of graduated springs, as described by Mrs. Guthrie Smith elsewhere in this book. At first these exercises should be used for the whole body, except the fractured limb itself. Only after the fracture has united firmly should exercises against resistance be started on the fractured limb.

In this place it is only possible to describe a few of the more important of these exercises, by way of illustration.

(*a*) *Thrusting exercise* (Fig. 178).—A strong tension-spring is fixed to an upright at the head of the bed, and a long sling is attached to the spring. The patient places his foot in the sling, the length of which is suitably adjusted by the rope. He then thrusts with his whole uninjured leg against the resistance of the spring, controlling the range and rhythm and the movement, by holding a loop in the rope and controlling the return of the leg to the flexed position. This excellent exercise strengthens the glutei, hamstrings and calf muscles, as well as the lumbar side muscles, and also re-establishes the thrust reflex, so important in walking.

This exercise may be started in the fourth week (on the uninjured limb), but the knee should not be fully straightened to the full tension of the spring before about the eighth week.

After the fracture is firmly united the same exercise is started on the fractured side (Fig. 179).

(*b*) *Hip abduction exercise.*—The foot is placed in the long sling as above. With the knee straight, the leg is steadily abducted against the resistance of the spring. This exercise may be started in the fourth week on the sound side, and after union on the injured side.

(*c*) *Calf muscles exercise.*—Long sling and spring arranged as above, with the knee flexed to a right angle. Only the fore part of the foot is placed in the sling ; the exercise consists of pushing the foot down (plantar-flexion) against the spring, which is " on tension " throughout the exercise (Fig. 76).

(*d*) *Head and neck exercise.*—A short sling is attached to the tension spring. The sling is adjusted over the occipital region and

FIG. 178.

FIG. 179.

EUTONIC EXERCISES.

These contrasting illustrations show vigorous exercise with the uninjured right leg (Fig. 178), and careful movements against mild resistance with the injured left leg (Fig. 179).

the movements of extension, side flexion, and rotation of the head are carried out against the resistance of the spring (Fig. 75).

Similar exercises to the above were also devised for the hip extensors, the peronei, the quadriceps, the anterior tibial muscles, and for the muscles of the shoulder girdle and upper limb. Exercises against spring resistance for the trunk muscles are described in other parts of the book, and the writer can testify to their usefulness.

Fractures of the Neck of the Femur

The Smith-Peterson nailing operation has simplified the after-treatment of these fractures to an unbelievable extent. Fixation of the fracture is so firm that splinting is quite unnecessary and the limb is left absolutely free in the bed.

Recumbent Stage.

Movements of the knee can be started two days after operation, and movements of the hip about a week later. Stiffness and wasting of the muscles, therefore, need never occur. The chief duty of the surgeon and physiotherapist is to persuade the patient to perform these movements. At first cramp-like spasms of the muscles are rather a nuisance and considerable determination may be needed to get full movement, in spite of them.

Knee movements are best carried out with the patient lying on the side, and at first the weight of the limb should be taken by a suspension-sling or the hands of the physiotherapist. The movements are increased daily, and by the tenth day the heel should touch the buttock. Fig. 164 shows the exercise.

By the end of three weeks full movements of the hip should also be re-established as illustrated in Figs. 162 and 163 in Chapter XII. Later the patient may be helped into and out of a chair by the side of the bed.

Weight-bearing must not be started before the eighth to the tenth week, and never before the radiograms show a fair degree of union.

It need scarcely be pointed out that the breathing and other exercises described under the first period of shaft fractures are

every bit as necessary in fractures of the neck. The exercises given under the second and third periods of shaft fractures can also be used for neck fractures, but, owing to the immediate firm fixation by the nail, there is less need for caution.

Ambulatory Stage.

The more efficient the physiotherapy in the recumbent stage the less the leeway to be made up when the patient gets up again. Exercises against springs and other resistances are continued until the muscles of the rest of the body, and finally of the fractured limb, return to normal, or as nearly normal as possible. From experience I can testify that *the extensors and abductors of the hip are the last muscles to return to their full strength*, and exercises for these muscles should be given special attention. They brace up the thigh on the hip in weight-bearing, and until they, and to a lesser extent the hip flexors, recover their full power, the patient is bound to walk with a limp. Attention must also be given to the muscles holding up the longitudinal, and transverse, arches of the feet.

Finally, there are two functions the return of which should be assisted by all available means. One is *correct walking* (without a limp), first with crutches, then with two sticks, one stick, and finally unaided. It is not necessary to describe the physiotherapeutic measures of walk-training in this place, as they are already well understood in physiotherapy. But I would like to emphasize the value of exercises on the *sloping board*,* and also of learning balance, and correct weight distribution by *walking on a straight line* in front of a full-length mirror.

The second function is *mobility of the knee joint*. Stiffness of the knee is the most troublesome and common disability after fractures of the femur. The only safe method of regaining movement is by active exercise, carried out by the patient's own muscles. Assistance may be obtained from apparatus, but *passive stretching of the joints must be absolutely avoided*.† The patient's best help is his own will-power, and our duty is to teach him patience and perseverance. There is no short cut to success, and progress is bound to be slow.

* *See* p. 285.
† *See* " Regional Exercises—Knee Joint." (Figs. 140–145.)

Chapter XIV

REHABILITATION IN THE FRACTURE CLINIC

REHABILITATION IN THE TREATMENT OF FRACTURES

By Margaret Roper, M.C.S.P., T.M.G.

(As carried out under the direction of V. H. Ellis, F.R.C.S., at St. Mary's Hospital, London.)

In this chapter an attempt has been made to outline the main aims and methods of treatment for the more common types of fracture. One in each group has been described in more detail than others, notably fractures of the femoral shaft and some fractures in the region of the shoulder. The general principles governing treatment of the upper and lower limb must vary slightly for obvious reasons. These two were chosen to illustrate this, and so possibly elucidate the sketchy outline of a very big subject.

The treatment of crush fractures of the vertebræ is also given in some detail, as it was felt that the suspension methods suggested were a helpful contribution to the otherwise well-known technique. Physiotherapy after removal of a fractured patella has been chosen to represent the operative group, as it illustrates how spring resistance may be incorporated with advantage in the treatment of knee injuries.

In most fracture cases surgical treatment and physiotherapy are very closely linked, and though the treatment is continuous, it may be grouped under three main headings :

(1) Reduction ;
(2) Fixation ;
(3) Restoration of function and rehabilitation to the pre-accident state.

Treatment is determined to a very great extent by the type of reduction necessary to overcome the original deformity and by the type of fixation to be used to maintain the position. Therefore fractures may be classified as follows :

Those requiring : Manual reduction.
Open reduction or operation.
No reduction.

Common examples of those requiring manual reduction are:

(1) In the upper limb: Colles and Smith fractures, some fractures of the metacarpals and phalanges, and, when they are angulated, fractures of the radius and ulna, the lower end of the humerus, and the clavicle.
(2) In the lower limb: most fracture dislocations of the ankle, some cases of fractured shafts of tibia and fibula, and comminuted fractures of the upper end of the tibia.
(3) In the trunk: crush fractures of the bodies of the vertebræ may be considered in this group, though the reduction is effected by the action of gravity rather than by manual manipulation.

Fixations for fractures after manual reduction

(1) Fixation by Plaster

Generally speaking this is obtained by plaster to include the joint nearest to the site of fracture and in some cases the joints at both ends of the fractured bone. For example, a Colles is usually fixed in a dorsal plaster slab extending from the heads of the metacarpals on the back of the hand to just below the elbow. It should be wide enough to grip the lower ends of the radius and ulna, but should not quite meet at the front of the wrist, in order that it may be released slightly should gross swelling occur. Subsequently the ends may be pressed towards each other as the swelling subsides, so that secure fixation of the lower fragments is maintained.

Fractures of the shafts of the tibia and fibula are fixed in an all-round plaster extending from the webs of the toes to the junction of the upper and middle one-third of the thigh.

Fixation is maintained in the upper limb for from four to six weeks, with the exception of the shafts of the forearm bones, which must be held at rest for at least eight weeks. The lower limb is usually kept in plaster for at least six weeks, and where a weight-bearing

surface is involved, such as the shaft of the tibia, for a minimum of three months.

Physiotherapeutic aims will be :

(1) As soon as possible to obtain full active range of movement in all free joints.
(2) To train static control of all muscles enclosed in plaster.
(3) Whenever possible, to encourage the normal use of the limb while it is still in plaster.

Where a weight-bearing bone is involved, such as the articular surface of the tibia either at the ankle or knee, or if the fracture is through the shaft, movement but not use of the limb is encouraged for the first few weeks. In these cases, static control and use of the muscles passing in the longitudinal direction of the limb is most important. As the muscles shorten in contraction they cause the bone ends to be pressed together, so giving a valuable irritating stimulus to the output of callus.

In fractures of the shaft of the ulna, gripping exercises produce this stimulant, and should be performed constantly to assist the union, which is notoriously slow in these cases.

After removal of fixation the aims are to mobilize the stiff joints, and to restore full normal function. Therefore, active and active-assisted movements should be performed, particular attention being paid to joints that have been fixed in plaster. Special exercises adapted to the needs of the patient, carefully graded in strength, range and stamina, should be practised during this period. A point to be remembered is that the strength of the exercises and the amount of weight lifted should be less for the first week or two out of plaster than during the latter period of fixation.

Exception.—In the upper limb an exception is made for the elbow joint. Only purely active movements are advisable. In some cases, if the patient is nervous, encouragement can be helpful, and suspension methods are useful, as the support given to the arm will enable patients to concentrate on the muscle control of flexors, extensors and rotators of the forearm. Instruction in relaxation may also be of assistance, but on no account should any force be applied to regain range of movement, nor should the patient be

allowed to perform tasks at home or at work which cause pain and fatigue.

Where the lower limb is involved, after removal of plaster, it should always be strapped with elastoplast before the limb is allowed to hang down. If applied evenly and firmly from below upwards, covering the same area as that previously encased in plaster, it will prevent œdema, but will not seriously limit the possible range of joint movement. Neither will it hamper the physiotherapist in giving assisted and passive joint manipulations, which are most helpful. Such manipulations are essential for the speedy restoration of ankle and foot mobility. After fixation in plaster, the joints having been held in dorsi-flexion, plantar flexion and inversion will be the most difficult movements to regain.

Details of Surgical Treatment for Crush Fractures of the Vertebra

Reduction.—When one or more of the vertebral bodies are crushed it is essential to restore the anterior depth of the body as nearly as possible to its original measurement. If this is not attempted, kinking of that part of the spine will occur, with subsequent disability, of severity relative to the deformity. This may vary from periodical pain due to pressure on nerve roots to complete paraplegia below the site of injury.

To ensure adequate reduction, the spine must be put into, and held, in a position of maximum extension. This is achieved by suspending the patient in the prone position by his arms and legs, the trunk falling by gravity into full extension. An anæsthetic is not advisable, as the relaxation is too complete, and an over-extended position is liable to occur. A plaster jacket is applied when extension is judged to be adequate, which will extend from the pelvis to the sternum, the armpits, and the mid-dorsal region. The fixation thus afforded must be retained for from three to four months.

Physical treatment : *Duration fixation.*—Whilst in the plaster it is most important to maintain tone and strength of all the trunk muscles, especially the erector spinæ. Treatment is therefore begun as soon as the plaster is dry, provided that there are no serious symptoms of shock or concussion.

Leg exercises are given for the few days that the patient may be kept in bed. Teaching of static control of the erector spinæ must be started during the first treatment. This may be done by passing a sling and spring resistance under the head (Fig. 75) and encouraging extension of the neck. This brings into play the upper part of the muscle. The lower part can be brought into play by rolling the patient on to the side, supporting the uppermost leg as in Fig. 163, either manually or by suspension, then teaching a full hyper-extension of the hip. This is repeated on the other side. Deep breathing as far as is allowed by the plaster is also encouraged,

FIG. 180.—Strong, free exercise for patient in plaster jacket.

with abdominal contraction on expiration which will start the training of the muscles of the abdominal wall.

Progression is made by rolling into the prone position and essaying to alternatively raise each leg backwards against gravity, holding the knee extended throughout. Head- and shoulder-raising, combined with external rotation of the shoulders, is also practised. The patient is now encouraged to get up and walk about, and should also be given a graduated progression of general exercises aimed at bringing all the muscles into play, remembering that the main aim is to be able to hold the position illustrated in Fig. 180 as soon as possible. To obtain these aims easily and pleasantly the suspension method is of great assistance.

Exercises in suspension to teach full active extension :

(1) Side-lying. Total suspension, body "anchored," both legs backward swinging.

(2) Side-lying. Total suspension, legs "anchored," body backward swinging.

(3) Same position but no anchorage, complete extension with legs, head and shoulders, arms first at the sides in external rotation, then in neck rest, and finally in stretch (Fig. 181).

FIG. 181.—Strong suspension exercise for patient in plaster jacket.

Resistance may now be added, either manually by the operator, who stands behind the patient and places one hand behind the head and the other behind the legs, or by attaching spring resistances to the head, arms and legs.

Exercises in suspension to activate all the trunk muscles and to give general body activity :

(1) Back lying. Total suspension, the legs being slung separately. Alternate leg abduction combined with pressing

down with the arm of the same side, followed by double leg abduction with both arms pressing down.

(2) Back lying. Total suspension as before, with spring resistance added, first to the arms by attaching a spring to the upright of the frame and then to the legs as well by fixing springs between the ankles.

(3) Side lying. Total suspension, flexion of the head, hips, and knees as far as the plaster will allow, with expiration on flexion and inspiration on extension (Fig. 182).

All the normal swimming strokes can also be practised with short, strong springs (not of the eutonic type) to give buoyancy. These are incorporated in each sling unit. Resistance to the movements of the arms and legs can also be afforded by attaching the resistance springs to either hand and foot, as occasion requires. (Fig. 24.)

These exercises are pleasant to do, and the variety made possible by the use of the apparatus greatly assists in maintaining patients' interest, encourages them to try other movements, work against increased resistance, and so continually spurs them on to further effort. All the other well-known exercises such as leg forward lying holding, trunk falling and raising, weight carrying on the head, trunk movements against weight resistance afforded by weight-and-pulley apparatus, and so on, should also be included in the treatment.

After removal of fixation.—Mobilization of the spine is the first aim in this stage, and later the return of full functional ability.

When the plaster is first removed, a spinal brace is sometimes advised which may be removed for treatment. In any case it is not advisable to allow flexion of the spine for the first week or two. Mobilization is greatly assisted, and is hastened by the use of the sling suspension apparatus.

To mobilize lateral movement

(1) *Position of patient.*—Back crook lying, total suspension with the trunk anchored and the hands in heave or stretch grasp to top of the plinth or the apparatus.

Position of operator.—The operator stands on the left of the patient, and supports the thorax between the right knee and

hand ; the left hand is placed on the right side of the pelvis. An active assisted localized mobilization for the lumbar spine is then given. The operator will then change her position and repeat the exercises to the opposite side.

(2) Free lateral swinging of the pelvis can also be taught, whilst the thorax is steadied as before or between the operator's hands.

(3) *Position of patient.*—Back lying, total suspension, legs and pelvis anchored, the arms grasping the ropes that suspend the thorax.

Position of operator.—As before, except that the pelvis is now held between the left knee and hand, and the right assists the movement which may be encouraged to take place in the thoracic region of the spine. Repetition is also made to the opposite side.

(4) Free swinging can also be practised whilst the operator steadies the pelvis with her hands or by a strap.

To mobilize rotation.—Though it is possible to mobilize rotation by placing the patient in sitting on one sling, as if on a swing, whilst the arms hold the ropes, it is questionable whether this is of any extra value, since the trunk normally rotates in this plane with gravity eliminated. Leverage can also be added very easily by use of a pole. High ride sitting with the pelvis strapped to the plinth, or sitting astride a stool with the toes tucked in behind the front legs are useful starting positions, as they fix the pelvis and limit the turning movement to the spine.

To mobilize antero-posterior movement (Fig. 182).—Extension should be free, but practice in attaining it from the neutral position is of value, as it initiates lengthening and shortening of the erector spinæ in its inner range.

The position of the patient is the same as for the active training in plaster, that is, side lying, total suspension, the legs and trunk being anchored alternately, and then the whole body freely suspended. When it is safe to mobilize flexion, the following exercises are of great assistance, since the movement can be done with gravity eliminated and therefore a good range of movement can be obtained before it would be advisable to allow forward bending with the whole of the weight compressing the site of recent fracture.

To mobilize flexion of the spine

(1) *Position of the patient.*—The same as for extension. Side lying, with the trunk anchored, the upper hand grasping the side of the plinth.

Position of the operator.—The operator stands behind and fixes the thorax between her right knee and right hand (if the patient is lying on his right side), and places the left hand on the back of the sacrum.

FIG. 182.—Patient "suspended" in preparation for mobility exercises. Flexion and extension of the spine; plaster jacket now removed.

She then instructs the patient to draw his knees up and try to round out the lumbar spine, at the same time giving gentle pressure on the sacrum, rather to guide than to force the movement.

(2) The legs are then anchored and the pelvis fixed by the operator. The patient folds his arms across his chest and bends the head and shoulders forward. Gentle pressure can also be given between the shoulder blades.

(3) The body is then suspended freely and complete flexion and extension of head, body and legs can be practised. The position of the arms can be altered as desired.

This is an extremely valuable " limbering " exercise, and involves a lot of muscle-work but no unequal strain on any part of the spine. (Fig. 25.)

During the final stage of treatment, when full mobility has been gained, strong trunk exercises must be practised and weight-lifting and carrying should also be included.

FRACTURE OF THE FEMUR

Fixation by Traction

Various types of apparatus are used to overcome the pull of the longitudinal muscles which causes overlap and displacement of the bone. The essentials common to all are :

(1) An apparatus to support the limb ;
(2) Some method of obtaining a sustained pull on the lower fragment ;
(3) Some form of counter-traction.

In these cases the traction acts as a method of fixation. Therefore, when reduction has been effected by manual manipulation under a general anæsthetic, the traction should be just sufficient to maintain the corrected position without separating the fragments. If this is not graded carefully and at the right time, overpull may lead to separation of the bone ends and non-union. This is especially so in fractured tibiæ, and for this reason many surgeons do not advise traction for such cases.

Details of the surgical and physiotherapeutic treatment for a case of fractured femoral shaft

Reduction and fixation.—If a Thomas's splint with weight-and-pulley traction is used, a wire is passed through the tibial tuberosity, the ends being held in a steel stirrup. A weight running over a pulley is attached to the stirrup to give constant longitudinal

traction on the lower fragment. The foot of the bed is raised so that counter-traction is provided by the weight of the rest of the body.

In this case the amount of weight necessary to maintain reduction may be up to 24 to 30 lb. When some union has occurred, the weight is gradually lessened to 10 to 14 lb., which is usually enough to keep the limb steady and fix the site of fracture. Care should be taken throughout the period of fixation that the weight is always hanging free, and nothing should be done that will interfere with its pull.

Immediate physiotherapy.—Breathing exercises should be taught, to expand the posterior basal area of the lungs and to increase the diaphragmatic and thoracic excursion.

At first this treatment is largely prophylactic, and the aim is to prevent any congestion in the lungs and consequent hypostatic pneumonia which is likely to occur as a result of the shock to the system, with consequent lowering of the blood pressure. The supine position necessary to maintain adequate counter-traction by body weight will obviously aggravate any tendency for fluid to collect in the posterior basal part of the lungs. Hence special attention must be paid to teaching localized breathing in this part.

Later treatment :

(1) *General exercises* for head and neck, upper limbs, trunk and the sound leg are gradually instituted as the patient recovers from the shock of the accident, and as some callus begins to form between the bone ends.

(2) *Special exercises* for the fractured leg, active toe exercises, and movements of the ankle and foot must be taught as soon as they can be performed without producing spasm of the muscles. This is liable to occur during the first few days.

After the first week, static contractions of the glutei and quadriceps are taught, and full range of ankle and foot movements should by this time be performed at frequent intervals during the day.

After second or third week.—The general exercises are continued, made stronger and performed more frequently.

The special exercises for the fractured leg are progressed to include the knee joint. Active assisted extension is first attempted

with manual assistance, leading on to the use of assistance by springs (Fig. 70), and finally free extension against gravity should be practised.

Method.—The operator places one hand firmly above the knee to give the patient confidence, and also to lessen the "drag" of the pin on the skin. The other hand is placed under the heel in order to assist the patient's effort to raise the leg. Later a spring and sling unit is passed under the ankle, and the patient is left to perform the movement without manual assistance. As the muscle control improves, this movement should be performed unaided, and at frequent intervals.

Assisted flexion can be started soon after the training for full extension has been begun.

Method.—The lower bandage slings which support the leg on the splint are removed from beneath the lower leg, which must be carefully supported. It is important to see that the sling immediately above and behind the knee is in place, to maintain support for the lower part of the thigh and prevent any bending of the soft, early union. The same grip is used as for assisting extension, one hand being above the knee and the other behind the heel, the patient being encouraged to press the heel down against resistance, which should be very slight at first. As the active control of the knee improves the support may be lessened.

If a Pearson bed is used, the lower section of the mattress can be removed and the straps of the bed undone so that as much of a right-angle flexion as possible can be obtained before the Kirschner wire is removed.

If a Pearson bed is not being used, after two months it is usually safe to raise the whole splint (provided the traction is not interfered with), and by fixing the hip allow more space for the heel to drop and so increase the knee flexion.

After removal of traction.—The limb is usually left on the splint, but the end of the bed is lowered. The leg may then be actively raised off the splint; abduction and adduction of the hip may be given in the splint. At first, knee flexion is still performed with the thigh resting on the upper slings of the Thomas's splint, which affords some support and guards against the tendency of the pull of the hamstrings to bow the femur at the site of fracture.

When the surgeon is satisfied clinically and radiologically that the union is firm, the splint is removed.

Some surgeons proceed to weight-bearing by use of a walking caliper; others keep the patient in bed for some weeks longer, until the union is firm enough for full weight-bearing. The subsequent description of treatment refers to the latter method.

PATIENT IN BED

(*a*) **Weightless exercises.**—Minimal active work.—Active exercises in sling-suspension with gravity eliminated. The aim at this stage is to restore a full range of movement, and to control that range by the patient's own voluntary effort; *i.e.* (1) Back lying (Fig. 183): hip—abduction and adduction; (2) Side lying (Fig. 184): Hip—flexion and extension.

(*b*) **Active work against gravity.**—The patient is now encouraged to lift the whole leg against gravity in all directions, especially in abduction and extension.

(*c*) **Active work against resistances,** either weight-and-pulley or spring resistance. These exercises aim at re-educating a balanced rhythmical action of weight transference from one leg to another, because this is an essential part of the muscle-work in normal walking.

"Walking in bed" (see Fig. 279)—*Method.*—The patient is suspended in slings from the pelvis downwards, with the trunk raised and resting on pillows, so that the whole body is horizontal but the lower limbs are free to move without obstructions. The resistance is arranged as follows:

one broad sling is placed under the buttocks two narrow slings under the thighs three narrow slings under the legs	By these the lower limbs are raised and suspended.

Two horizontal ropes with springs incorporated (or running over a pulley with weight attached) are fixed to the feet. These must lie parallel with the legs. The other end of the rope or the pulley is fixed beyond the patient's shoulders to the top of the bed-head. The patient presses down, using the sound and injured leg alternately, and aims at stretching the spring (or lifting the weight) as far as, and for the same amount of time, with each leg. This exercise aims at gaining *equal muscle action,* accurate timing of

FIG. 183.—Weightless active movement. Hip abduction and adduction.

FIG. 184.—Weightless active movement. Note large range of hip movement in flexion.

the contraction and relaxation of the weight-bearing muscles, and prepares for the " feeling of walking " in a rhythmical manner. It also helps to demonstrate that the injured leg can do the same amount of work as the sound one, and so precludes any psychological tendency to a limp.

Patient out of Bed

Partial weight-bearing exercises.—The " walking exercises " are continued, if necessary adding extra strength to the resistance, preferably weights, but the main aim is to train even weight-bearing on both feet.

(*a*) *Sloping board.*—Graduated exercise by using a sloping board is invaluable, as it teaches weight-bearing on the feet and legs alone. Aid from the arms is not necessary as it is when using sticks or crutches. The board is a single plank 18 in. × $6\frac{1}{2}$ ft., with a right-angle foot piece about 18 in. long at one end. At the back of the other end strong hooks are fixed to fit over wall bars. (See diagram of a similar board used as a massage plinth. Fig. 259.)

In this way the board can be arranged to be nearly horizontal at first, and is then gradually fixed to higher rungs until it is nearly vertical. Throughout the exercises the patient practises " standing " first on one foot and then on the other, being careful to raise the pelvis equally on both sides throughout. Then alternate knee raising and alternate leg abduction are practised, still gaining an equal pelvis lift as the weight is transferred from one leg to the other. When each of these simple movements is mastered with an equal pelvic lift on both sides, the board is raised a rung at a time until it is vertical in position. The exercises are then practised in standing, and a few steps are allowed, still maintaining the even balance and control of the pelvic tilt throughout.

(*b*) *Using crutches.*—If patients are sufficiently sensible, walking with the aid of crutches is permitted before full unaided weight-bearing is allowed. This should be carried out by emphasizing the even movement of both legs, as assistance to the weight-bearing is given by the crutches. These should be placed in the forward position at the same time as the injured leg is carried to the front. Care should be taken to see that the injured leg is kept parallel with the sound one, and not allowed to slope outwards. For such

cases a marked pathway and a mirror are useful aids. Later the crutches may be changed for sticks. These must be retained until a perfectly even walk is accomplished. It is not advisable to allow only one stick, as it tends to encourage a one-sided lean towards that side. If one stick is used, it must always be held in the opposite hand to the injured leg.

(*c*) *Strong work*.—Lastly, all patients should be trained to go up and down stairs. Younger folk should have balance and spring exercises, practice in ladder climbing, and weight carrying if their work demands this type of activity.

FIG. 185.—Re-educating knee movement by weightless exercises.

The knee joint (Fig. 185).—Little has been said about the limitation of movement in the knee joint, so often an aftermath of a fractured femur.* If this stiffness persists, special exercises with pulleys and springs must be practised throughout the course of rehabilitation to try to overcome this most trying disability (as suggested in Chapter XI on "Knee Exercises" (Figs. 141, 142, and 143)).

* According to R. H. Young, F.R.C.S. (*Proceedings of the Royal Society of Medicine*, Sept., 1942), if 35 degrees of flexion can be obtained during the first six weeks the subsequent stiffness will not be severe or of long duration.

Fractures requiring (1) open reduction or (2) operation.

(1) Badly displaced heads of humerus, radius and ulna.

(2) Smith-Petersen pin for the neck of the femur. Suture or removal of part of the olecranon, or removal of the patella, and screw fixation for grossly displaced greater tuberosities of the humerus.

Fixation.—No external fixation is necessary, as the fragments are held internally by screws, pin or sutures; or if, as in the case of a removal of fragmented patella, the soft tissues are held by catgut.

Physiotherapy.—Physiotherapy can start as soon as the soft parts are united by fibrous tissue, *i.e.* in about 7 to 10 days. Full rehabilitation follows in three to six weeks. After insertion of a Smith-Petersen pin, and sometimes after fixation by screws, movements can be started as soon as the patient has recovered from the effects of the operation, but weight-bearing for Smith-Petersen pin cases is not usually allowed until there is evidence of good bony union. (For treatment, see Chapter XII, Exercises, Grade A (1).)

Details of treatment after removal of patella

This operation is now performed fairly frequently, as most authorities consider that not only is the disability period less after removal of the patella, but the prognosis for ultimate functional ability is better than if the fragments are wired together.

Surgical treatment.—The fragments of the fractured bone are removed and the tendinous expansion is sutured together. A firm pressure bandage is applied.

Physical treatment.—The main aims in this condition are to teach, first, full active extension of the knee and then to restore full flexion. Good muscle control is therefore very important, and the sooner the patient can be taught to appreciate this the better. Normal strength of both hamstrings and quadriceps is also necessary if a perfect functional result is to be obtained.

Physiotherapy can start within the first week after operation. The pressure bandage should not be removed. Active foot movements are first taught, then static contractions of the gluteus maximus, and finally the most important part of the treatment: static

control of the quadriceps. Faradism is of great assistance here, but for the first few days it must be given gently, and a full contraction should not be attempted until ten to fourteen days after the operation, when there will be sufficient fibrous formation to bear the strain. The patient is encouraged to reinforce the contraction caused by the faradic stimulation, and to hold it after the current has been withdrawn. By this means control of the quadriceps in the shortened position, which is so important, can be gained. At this stage the use of resistance springs is invaluable, as the exercise can be repeated hourly without supervision. A simple practical method is to pass a flannel bandage behind the knee and to attach it to a spring which in its turn is suspended from the cradle. A small range of movement is possible by pressing against the spring, as the knee is usually held in the relaxed position of slight flexion. The spring, by giving slight resistance, directs the movement.

Active training of the hamstrings is next instituted, if necessary, with careful faradic aid. Again a spring will be a constant stimulant to the effort, so the bandage is passed under the heel, and a spring is suspended to the lower end of the cradle. As the patient exerts pressure with the heel against this lower spring, the hamstrings are brought into play. Constant interaction between these two groups can thus be practised.

After about ten days attempts should be made to lift the leg from the bed holding the knee fully extended. When this can be done with a reasonable degree of control, it is usually assumed safe for the patient to stand, and to start walking. Before weight-bearing is allowed, however, some attempts must have been made to flex the knee. This should not be started until the surgeon gives permission, as the degree of laceration of the tendon before operation will influence the time when it will be safe to put any stretching strain on the suture. Flexion is best taught in side-lying, with the leg supported in slings (Fig. 185), as in this way a weightless exercise can be performed, and the comfort and feeling of support minimizes the likelihood of a sudden spasm of muscles which would be harmful.

Walking should first be taught with the aid of sticks to give confidence, and eliminate the danger of tripping or slipping. Normal use of the affected leg must be taught from the beginning,

as the natural interaction between flexors and extensors of the knee in walking is the best method of re-educating the control of these muscles.

Exercises with resistance of gravity and of springs can now be introduced, but no attempts at forcible flexion should be attempted. Even a double knee pulley is not advised, as the knee, like the elbow, is very easily irritated after direct injury.

If, as is often the case, absolutely full active extension against gravity is found to be difficult, a useful adjustment of the springs is of assistance. One sling-and-spring resistance is fixed round the thigh with a strong spring incorporated. Another with a lighter spring is fixed to the heel. By this means the strong spring gives the necessary guiding stimulus to combined extension of hip and knee as the thigh is pressed down, but as the balance is upset by the quadriceps being relatively weaker, the second spring assists in the upward movement of the lower leg which is performed by these muscles. Combination of Figs. 141 and 142 will achieve this.

Bicycling, rowing, weight-lifting, heels raise, knees bend, and all the usual rehabilitating exercises for the knee may be instituted during the second month of treatment. Full restoration of function should occur within three months.

Fractures requiring no reduction

1. Greenstick fractures

Most greenstick fractures come into this category, as do fractures of the tarsal and carpal bones, and some Colles fractures which are firmly impacted but not grossly displaced.

Fixation is usually effected by plaster, and is maintained for a period of three weeks to three months, according to the amount of strain the bones have to bear or the time they take to unite.

Exceptions.—Fractures of the os calcis (calcaneus).

These cases are not usually reduced or fixed in plaster. No weight-bearing is allowed for at least three months, the usual time necessary for complete consolidation, but movements must be begun as soon as possible, and maintained throughout the non-weight-bearing period.

2. Fractures of the neck of the humerus

(*a*) *Impacted fractures.*—When there is impaction, reduction is not advised, since the force required to effect an adequate reduction would cause more injury to soft parts. The slight disability and limitation in movement which may persist if there is much deformity does not warrant any attempt to obtain perfect anatomical alignment. Fixation is not necessary either, and an armsling will ensure adequate rest and support.

(*b*) *Non-impacted fractures.*—If the fracture is not impacted, and the arm is held by a collar and cuff sling so that the upper arm hangs vertically at the side, the weight of the arm is usually sufficient to effect reduction by continuous traction on the lower fragment. Sometimes the weight may be increased by applying plaster to the lower arm. The plaster can be removed when the alignment of the fragments is considered to be adequate to obtain a good functional result. Some extra support may be given during the first few days by applying a horizontal bandage round the body to include the upper arm. Care should be taken if this is done to see that the hand and wrist are free, and that there is *no* support under the elbow.

Physical treatment.—In these cases the treatment will vary in the initial stages, but later on will follow the same lines.

(*a*) *Early treatment of impacted fractures.*—Where the bones are impacted sufficiently firmly for movement to be performed without crepitus, the fracture may be considered as secondary to the injury to the shoulder joint.

The main aims of treatment will therefore be : (i) to relieve pain and muscle spasm ; (ii) to reduce œdema and prevent organization of hæmatemata ; and (iii) to restore the full range of joint movement *as soon as possible.*

Throughout the early treatment, however, it must be remembered that the joint is inflamed, and therefore, though it may be taken through its full range of movement, this should be done *once and once only* at each session.

Method.—The patient should be in the recumbent position, with the arm and head comfortably supported by *firm* pillows. Instruction in relaxation is given, aided by breathing, infra red (or some other form of heat) and soothing massage ; slow rhythmical

kneading is generally found to be most helpful. Fingers, wrist and elbow are then put through a full range of active movements, which may be assisted at first to restore the patient's confidence. Next, active assisted movement is given to the shoulder itself. This must be done slowly and carefully, with a pause when pain causes spasm of muscles. As this subsides a further few degrees are essayed, and so on until full elevation is obtained. No force whatsoever must be applied, and throughout the manœuvre the patients should be made to realize that they really are performing the movement themselves. The grip advised for this method is illustrated in Fig. 186. Flexion and extension in abduction are

FIG. 186.—Special grip for early treatment of impacted fracture of the neck of the humerus.

given as the arm is being lowered from full elevation, and internal and external rotation are performed either at the beginning or the end of the session, when the arm is resting at the side and the elbow is fully extended.

(*b*) *Early treatment of non-impacted fractures.*—In these cases the fracture has to be considered first, and the range of shoulder movement second in importance during the initial stage of seven to ten days. Movement, however, should be given, but in this case the arm must be kept in the vertical position throughout the treatment, at any rate whilst the shoulder is being moved. The patient is therefore sitting, the wrist still resting in the collar and cuff. Movement at the shoulder is brought about by the patient bending the body

sideways so that the arm hangs away from the side into abduction, forward so that the arm falls forward into flexion, and backwards so that extension at the shoulder occurs. The operator should have her fingers in contact with the head of the humerus throughout these movements. After seven to ten days, provided no crepitus is detected, the recumbent method used for impacted fractures may be employed to obtain a fuller range of movement.

3. FRACTURES OF THE GREATER TUBEROSITY OF THE HUMERUS. Unless they are very grossly displaced, these cases need no reduction or fixation, and are treated in the same way as the impacted fractures of the neck of the humerus.

Aims of treatment common to all three mentioned above

(1) To relieve pain and muscle spasm, and to aid absorption of exudated fluid by means of relaxation, heat and massage.

(2) As soon as possible to restore full range of movement at the shoulder, and maintain that range by assistance until the patient can perform the movement unaided and against gravity.

(3) From the beginning of treatment to re-educate the active muscle control of the whole arm and especially of the shoulder. This is best done in the early stages with gravity eliminated and by assisting the movement and giving support to the fracture in the same way as when the assisted movements to restore joint mobility are being given. Pure deltoid control is the most important in the early stages.

(4) To restore the normal strength of these muscles. This should be started with the patient in sitting position whilst the operator assists the active anti-gravity movement. The patient is then instructed to hold the position without any support. Again pure deltoid control is most important, as there is always the tendency to overuse the shoulder girdle to save the humero scapula joint. Pulley exercises can be of great value at this stage, but they must not be given too fast or for too long a period to begin with. This is especially the case in fractures of the great tuberosity, as the friction caused by the repeated movement tends to increase the pain, and consequently may lead to protective muscle spasm and loss of range of movement. Static holdings and controlled con-

centric and eccentric movements before a mirror are most valuable for all cases. Stick exercises, and all the well-known self-assisted exercises are also helpful.

(5) The last aim is to restore full functional ability, and therefore final exercises adjusted to the needs and age of the patient should be taught. These will include the use of Indian clubs, ball exercises, graduated weight-lifting, rope climbing, and hanging from wall bars. Occupational movements, such as shovelling loads of sand or swinging a heavy hammer, etc., are simple examples of this type of exercise.

Other common shoulder injuries.—Dislocations and sprains or strains of the tendons round the shoulder joint may be added when fractures in the region of the shoulder are being considered. Dislocations of the humero scapular joint are often combined with fracture of the great tuberosity, and the symptoms of supraspinatus strain, which seems to be the most common tendon injury in this region, are very much the same as those of a contusion fracture of the great tuberosity.

The dislocations have obviously to be reduced, and if the supraspinatus tendon is grossly torn or ruptured, it must be repaired by surgical means before restoration of function by physiotherapy can be initiated. The aims of treatment are the same for these conditions as for the fracture cases, but there are a few slight differences in the technique which it is important to remember. For instance :

Dislocated shoulder.—When giving active assisted elevation to a recently dislocated shoulder, great care should be taken that the operator's thumb is really in the axilla, and can detect the movement of the head of the humerus. The support should also be real as opposed to what might possibly be called moral in the other cases, and should also be continuously in the upward direction, *i.e.* during all phases of the movement the humerus must be pressed towards the glenoid. Great care should also be taken to see that the arm is held close to the side of the face throughout the above shoulder level part of the movement, and no external rotation combined with abduction should be given for at least seven days after the injury. External rotation in adduction and abduction with the humerus in the mid position may be safely

given, and active muscle control must be emphasized from the very beginning of treatment. A sling is the only form of support that is necessary. It is usually safer inside the clothes for the first few days.

Injuries to the supraspinatus muscle.—These are extremely painful injuries, and opinions vary as to the best method of support in the early stages. If a sling or abduction splint are used, the treatment will be the same as for other shoulder injuries, but faradism to the supraspinatus has been found to be of some help. This must not be given too forcibly, nor must it be given for too long, as it will increase the pain. A safe rule is to start with three gentle contractions on the first day, and then add two on each successive treatment until twenty contractions are being given, and then continue with this number daily until the symptoms subside. During the later stages, graduated re-education of voluntary control is most important, but pulley exercises should never be instituted until the pain at night has ceased.

Chapter XV

REHABILITATION IN THE CHEST UNIT

BREATHING EXERCISES, THEIR TECHNIQUE AND USES

In this chapter only an outline can be given of a new and important branch of Rehabilitation—that of the work carried on in the "Chest Hospital." Though breathing exercise and postural corrections have always been included in the basic training of physiotherapists, their new development to pre- and post-operative treatment for chest conditions are rapidly becoming a speciality. The technique is now so well thought out, and so detailed, that further knowledge of the anatomy of the chest wall is necessary, and is revised before the exercises are dealt with.

The author is grateful to A. F. Foster-Carter, D.M., B.Ch. (Oxon.), of the Brompton Hospital, for very kindly revising this chapter, and to two of the leading physiotherapists in this type of work, Miss Linton and Miss Reed, for writing notes on post-operative cases under their care at the Brompton and Harefield Chest Hospitals, and also for some details about breathing exercises given in this chapter (see p. 299, points (1)–(7) and p. 305, points (1)–(6)). Their articles on surgical cases appear at the end of this chapter.

The Neuro-Muscular Mechanism

It is through the *neuro-muscular mechanism of the chest* that immense possibilities of obtaining better and freer movements of the chest-wall are being developed in the technique of breathing exercises. Under the guidance of the physiotherapist the patient is trained to control the mechanism.

The act of respiration is in two parts: Inspiration and expiration; and although respiration is primarily of a rhythmic, involuntary and unconscious character, *it can be accentuated by the will.*

The lungs are elastic structures, held out by the vacuum in the thorax, and are continually under tension. This tension deflates them in expiration when the pull of the chest wall is released and will collapse them completely if the pleural vacuum is

destroyed. Thus the lung is not " pushed in " on expiration, but allowed to deflate. It is like a bellows with a spring. Inspiration is inflation of the bellows against the spring, while in expiration the pull is released and the spring empties the bellows.

" The pleuræ are double sacs attached to the lungs and to the chest-wall ; in this way the lung is bound to the chest-wall by an ' atmospheric ligament which acts in the same way as a rubber sucker ' (Keith). The weight required to separate the visceral and parietal pleura over the lungs amounts to a ton ; this is far greater than any force that the inspiratory muscles can bring to bear ; hence by no muscular effort can the pleural bond be broken." (Hutchinson's *Applied Physiology*.)

By careful training and mental concentration on the movements of the essential muscles of the chest and the diaphragm, the patient can be directed " to think " of drawing air into the lungs and to direct it to the particular spot under the physiotherapist's hand, so as to fill this area with air.

Expiration is chiefly a passive movement ; the chest-wall tends to resume its former position after inspiration ceases, the elastic lungs recoil, and the relaxed diaphragm is drawn up by negative pressure. To encourage forced expiration the abdominal muscles must consciously be contracted and the spinal column relaxed. This pressure on the viscera aids the ascent of the diaphragm ; also the intra-abdominal pressure is increased by the contraction of the abdominal muscles.

Work on applied physiology gives us some facts of great practical interest. One of these is that although the lung is " passive " there is not equal movement in all its parts ; it is stated that there are three zones of movement * :

KEITH'S ZONES

(1) *A root zone.*—Structures which make up the lung root are artery, bronchus, vein, lymphatics and nerves. This area does not expand, but it moves downwards, forwards, and laterally during inspiration.

(2) *A zone of tissue*, where the blood vessels radiate in lung tissue from the root to the surface. This area gets more and more expansile as it gets near the surface. (The bronchi have the power of being elongated during inspiration and look like rays, lengthening and shortening.)

(3) *An outer zone* one or more inches deep round the lung, which is the area of *maximal distensibility*.

* These notes are taken from *The Physiological Basis of Physical Medicine* (Best and Taylor.)

Those parts of the lungs in contact with the spine, the mediastinum or the apex can only be expanded *indirectly*, but those in contact with the boundaries, diaphragm, ribs and sternum more freely and *directly*.

" The thoracic lid " is a name sometimes given to the uppermost thoracic joints, consisting of the first pair of ribs and the manubrium sterni. Jointed behind to the spinal column, the whole of this composite attachment appears to move as a single piece, assuming a more horizontal position on every inspiration. The amount of movement varies in different individuals, ranging from 1 to 16 degrees. The manubrium moves upwards and forwards and therefore increases the thoracic cavity from before backwards. The thorax moves as a *whole* and *not* in three separate parts ; the different movements of the three zones grade into one another. The upper chest movement (1st and 2nd ribs and manubrium) is *predominately* upwards and forwards, while farther down the lateral (bucket handle) element becomes more and more marked, so that the lower ribs are almost entirely concerned with lateral expansion.

The upper costal series (2nd to 5th ribs) rotate round an oblique horizontal axis, parallel to the neck of the ribs. As the ribs move they become more horizontal in direction ; this thrusts the sternum forward and upward (again moving the sterno-manubrium joint) and increases the chest diameter from before backwards.

6th to 10th ribs (lower costal). The mid portion of each rib becomes elevated in relation to its two fixed ends (bucket handle movement). In this movement they widen the subcostal angle and increase the transverse diameter of the chest.

The abdominal muscles and 11th and 12th ribs.—Functionally the floating ribs must be considered with the abdominal muscles which are the antagonists of the diaphragm. *The recti* and *oblique muscles* relax as the diaphragm descends, and they contract with its ascent.

The muscles of ordinary inspiration are the diaphragm, intercostals, levatores costarum and the scalenes. The latter pull on the upper ribs ; the external and internal intercostal muscles are obliquely arranged in series with their corresponding abdominals ; and it is interesting to note that their oblique attachment gives

them a "mechanical advantage," so that their upward lifting movement is facilitated by this arrangement of their fibres.

By the combined action of the thoracic muscles the air-tight chest is enlarged downwards, forwards and outwards ; the vacuum thus formed will be filled partly by blood within the large venous trunks, and partly by air in the lungs from the air passages.

The diaphragm moves like a piston—up and down. It is in contact with the chest wall as high as the 5th and 7th ribs at the end of expiration. On inspiration it is "peeled off" the thoracic boundary and the base of the lung expands to fill the space at once. The costo-sternal part of the diaphragm moves downwards and forwards, pushing the abdominal viscera before it. Thus the lower part of the thorax is increased in size.

The abdominal wall distends, but when as a result of the resistance offered by the abdominal muscles, the downward movement of the viscera becomes arrested, these organs act as a fixed point for the continuing contraction of this part of the diaphragm. The posterior part in its descent acts solely in increasing the vertical diameter of the thorax.

The excursion of the diaphragm is consequently influenced by : (*a*) the negative (sub-atmospheric) pressure of the thorax ; (*b*) the intra-abdominal pressure.

Anatomical Breathing Exercises

These facts should be carefully noted, as they give the key to so much of the technique and anatomical possibilities of breathing exercises, and they give the physiotherapist a vivid impression of the internal functioning of the respiratory tract while the outer stimulus to the chest wall is being administered.

The muscles of the chest-wall, like all other muscles, will *work best against resistance.* Even in normal people full use of these joints and muscles is seldom obtained ; therefore those with chest disabilities will improve greatly if they obtain mastery over this mechanism.

The breathing exercises.—Exact pressure is applied by the physiotherapist over the area of the ribs ; the hand is moulded to fit the part and pressure is carefully graded so that the muscles

work against resistance. In this way a very localized action is obtained and the normal inspiratory movements can be greatly augmented.

(1) For upper lobe expansion the pressure is partly lateral, just below the arm-pit and partly anterior, immediately below the clavicle.
(2) For right middle lobe expansion, antero-lateral pressure is given, because the middle lobe lies very much to the front.
(3) For the posterior basal area, pressure is given posteriorly.
(4) Exercise of the uppermost area will influence the anterior portion of the *apex of the lung*. The manubrio-sternal joint should be kept as mobile as possible as it does not stiffen naturally until about sixty-three years of age.
(5) With regard to the area 2nd to 5th ribs, expansion in an antero-lateral posterior direction can be aimed at.
(6) For the area 6th to 10th ribs these parts can be trained to expand in an antero-lateral direction.
(7) For diaphragmatic breathing the physiotherapist's hands are placed at the costal margin and gentle pressure is given to localize the breathing at this point for light inspiratory movement, or for deeper breathing.

Breathing and muscular exercise.—The circulation rate is increased during muscular exercise as the greater proportion of the blood is drawn through the muscles; the red cell unloads more of its oxygen. CO^2 excess in the blood is the chief controlling factor; this influences the respiratory nervous centre, which is also affected by the afferent fibres of the vagus nerve. These influence the depth and rate of breathing, also, further afferent impulses from the skin, which are sensitive to chemical and nervous factors, have their effect as well; emotional factors also play a part.

The effect on the abdomen caused by movements of the diaphragm and other respiratory muscles will be to set up a varying pressure in abdomen and chest. This pressure exerts a powerful influence on the great veins within those parts, and blood is both pushed and sucked up into the mediastinum. Thus the circulation is stimulated to a marked degree. The varying pressures set up

will directly affect the digestive tract and promote the functions of digestion and absorption.

As the result of illness and inactivity the respiratory system and organs will be working at a minimum, and the interchange of gases both in the lungs and tissues will be at their lowest. The bases of the lungs tend to become œdematous and predisposed to pneumonia ; shallow breathing causes deficient oxygenation of the blood, physical lassitude and mental apathy.

Breathing exercises will therefore be indicated, and ordered, for general post-operative conditions ; at the puerperium, and for many medical conditions, as well as for special conditions such as the following.

Treatments

Bronchial asthma.—The heavy deposits of mucus which remain in the chest after an attack of bronchitis often aggravate a reflex spasm of the bronchial muscles, this tends to close the bronchial tubes and prevent the passage of air through them. The strain to expel the sputum brings on an associated attack of asthma ; the patient feels a choking sensation and gasps for breath. Inspiration is comparatively easy, as the pull of the thorax tends to lessen the bronchial spasm, and, feeling relief, the subject takes yet another breath, so that the respiration becomes rapid, very shallow, and occurs almost entirely in the upper chest. On expiration, the pressure and weight of the chest increases the spasm, and makes a full expiration impossible ; thus a vicious circle is set up which if it is continued without relief, would gradually alter the whole capacity of the lung to function properly.

The sufferer from bronchial-asthma reveals many faults of posture and respiration, which *must* be corrected. The shoulders are held stiffly, and the dorsal region of the spine is often kyphotic, and held in a rigid manner ; while the breathing is chiefly carried out with the upper chest.

Remedial exercises should be given between attacks of asthma, and should be directed to overcoming the local disabilities. *For stiff shoulders* a good rehabilitating exercise is one in which the patient carries out bilateral pulley exercises, as illustrated in

" Regional Exercises." Also free shoulder rolling, arm raising and stretching can be performed in classes.

Dorsal spine kyphosis.—If the patient relaxes in stoop sitting the dorsal spine will be stretched; then, if the back is raised vertebra by vertebra until straight, mobility will gradually be aided.

To tone up the muscles of the head and neck, head extension in lying, against resistance of a spring can be given, and is easily carried out under supervision; at the same time the kyphosis will be corrected without undue fatigue. (Fig. 83.)

Balance exercises should be given to children for correction of head posture. Class work is invaluable and large classes of asthmatic patients are held at the Brompton and other hospitals.

The value of expiratory exercises.—As the asthmatic subject so frequently snatches or gasps to get his breath, he brings into use all the upper chest muscles and joints; the upper part of the lung will be used fully but very little effort will be made by the deep-lying bases and lateral regions. The dyspnœa of asthma is due to this faulty breathing, as too much residual air remains in the lungs.

In normal people the proportion of residual air is only one-third of the whole, while in the asthmatic it may rise to very great proportions. Thus it is essential for them to breathe out as much of the stale air as possible, with expiratory exercises.

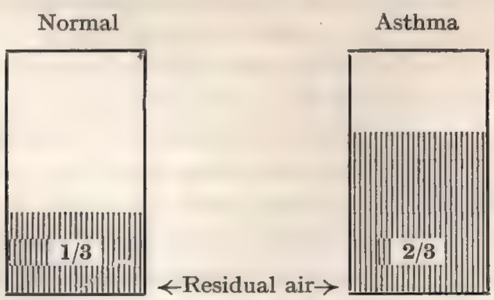

Fig. 187.—Contrasting areas of residual air in normal and asthmatic subjects.

The chief consideration is how to carry out these expiratory exercises without causing too much fatigue or fresh attacks of asthma. The solution appears to be :

(1) To encourage diaphragmatic breathing, using the anterior portion of the diaphragm, so that a *small* controlled movement is established in the midriff. This quiet controlled breathing is accompanied by long expiratory breaths ; the patient lets out the breath by whistling or hissing noises between the lips or teeth. It should be explained to the patient that the lungs are too full of spent air, and the importance of changing this air as often as possible should be made clear. (This type of breathing is quite new to the asthmatic, as in his endeavour to obtain his breath the upper region of the chest is usually the only part that has been in use.) Therefore this expiratory exercise must be most carefully taught and supervised by the physiotherapist.

(2) The patient should also be taught to press on the lower ribs, with the hands placed one on either side, and get a local expression of air in this region.

Frequent use of these remedial measures will not cure asthma, but a better capacity will be built up in the chest, so that the residual air is more constantly changed, and in some cases the attacks of asthma are prevented, postponed, and may finally cease.

(3) Relaxation should be practised with quiet breathing. This will help to restore confidence, especially if a patient is carefully trained. An attack can sometimes be delayed or arrested if the patient can relax thoroughly, and often the habit of awakening at a fixed hour in the night can be overcome if quiet breathing and relaxation are carried out before going to sleep.

(4) An essential measure of great value for asthmatic subjects is *chest clapping*. The percussion assists the local interchange of gases in the lung tissue, and removes products of fatigue in the tired muscles which are used in excessive coughing. It also loosens mucus in the mucous membrane, and thus aids expectoration.

For bronchial-asthmatic subjects gentle clapping tends to ease spasm if it is gently applied on all surfaces of the back and chest, while the patient is in lax-stoop position. In all respiratory conditions it is most important to study the comfort of the patient with regard to posture when giving chest clapping, and not to insist on the " classical " positions of neck-firm, head-support, etc., as they are quite unsuitable for these cases.

Clapping has a refreshing effect on the muscles of the back and on the intercostals, and helps to remove the fatigue products which must be present after frequent bouts of coughing.

The physiotherapist can also do a great deal to relieve the discomforts suffered by the bronchial-asthmatic patient, by certain manually applied manipulations; three such movements are suggested:

(1) The small respiratory joints can be mobilized by applying pressure exactly over the angles of the ribs. The palms of the hands work in alternating pressure-movements from above downwards. The rib-angles are used as levers to obtain the necessary pressure on the joints. The costo-vertebral and costo-transverse joints lie close to many lymphatic vessels; this manipulation will therefore not only improve the mobility of these joints but it will reach deep-lying lymphatics and blood vessels; thus the circulation will be improved and stasis removed in the deepest structures.

(2) Every intercostal space can and should be massaged by deep stroking movements of the thumb (deep, firm pressure will not tickle). The movements must be in ever-increasing oblique lines, in order to follow the exact line of the anatomical structures.

In each rib space lies an artery, vein, nerve and a mass of lymphatics. The nerve is the most superficial, so if there is any question of neuralgia or neuritis being present the work should be very slow and soothing, with light pressure. Where there is fibrositis or congestion then more vigorous work will remove effusion and assist the congested area.

(3) If deep pressure is given over the lower four ribs in time to the patient's respiration, the residual bronchial-catarrh which tends to lurk in the bases of the lungs will be shifted and coughed up.

This movement can be carried out in much the same way as in the application of artificial respiration: the patient lying prone, with face turned to one side, or sitting leaning on a table, the folded arms supporting the head. The operator presses on both sides of the bases of the lung at once, and as evenly as possible during the expiratory periods of respiration. This evenly applied mechanical pressure must expel more residual air than it is possible for the patient to expel by active means alone, and it is suggested that this manipulation should be given at the start and finish of

treatment for suitable cases and in conjunction with expiratory breathing exercises of an active nature.

Secondary emphysema.—Emphysema may follow as a sequel to respiratory diseases such as asthma, bronchitis and pneumonia. The alveoli become over-distended, and lose their elasticity. Once elasticity is lost it will not be possible to maintain the varying pressures which exist in the normal chest. Emphysema destroys the normal elasticity of the lung which is responsible for its deflation in normal expiration. Therefore the chest becomes fixed in the inspiratory position, as if the subject had just taken a deep breath. The negative pressure in the normal pleura is produced by the elastic tension of the lung, which tends continually to pull against the chest wall. If this elasticity is destroyed the negative pressure will be reduced, with results as stated. As soon as the negative pressure of the thorax is lessened stasis will occur in the portal circulation, as well as the respiratory tract itself. The indications for physiotherapy will therefore be to teach expiratory exercises, and to assist to " push in " the chest wall with vibratory pressures, and to apply percussion movements over the side and lateral aspects of the thorax. Also to stimulate the diaphragm, especially in its upward movement, by adding abdominal contractions on the out-going breath ; and to give massage for the liver and colon, so that stasis is prevented. Finally, the patient should be taught as many rehabilitation exercises as possible, selecting those which will tend to stimulate the liver and intestines.

Self activity for emphysema.—" A good exercise is to climb a hill, rest after five steps, inhale a breath and exhale slowly, and while exhaling compress the thorax with both hands placed over the lower ribs ; sounding the letters OU or EE while exhaling." *

Bronchiectasis is often a sequel of pneumonia ; it is characterized by very offensive sputum. The diagnosis of this complaint is now greatly assisted by injections of an iodized oil called lipiodol which is injected into the bronchial tubes and makes them opaque to X-rays. In this way cavities and abscesses are made visible. In very severe cases it may be necessary to remove a lobe, if one is seen to be grossly infected ; in other cases physiotherapy is tried. Coughing is encouraged, after the patient has been placed in a

* Krusen in *Physical Medicine.*

posture which will tend to drain the affected area. Percussion movements are then applied to the back and sides of the trunk, in order to encourage expectoration, and the treatment is carried out every four hours, every day if possible.

Posture is attended to so that scoliosis will not occur, and the shoulder joints are not allowed to stiffen.

Postural Drainage.—Following an examination of the X-rays the surgeon or physician will direct the appropriate position to be taken during the application of physiotherapy, so that expectoration will be assisted to drain down the large bronchial tubes.

Generally speaking, the best drainage postures * are as follows :

(1) The upper lobe ..	With the patient sitting.
(2) The middle lobe ..	Patient lying flat on the back. Foot of bed raised 12 in.
(3) The lower lobe ..	Patient tipped up on a special bed.
(4) For posterior aspects of the lobes.	Patient prone lying or over the side of a bed or over a frame—angle of 35 to 45 degrees.
(5) For the anterior aspects of the lobes.	Back lying.
(6) Lateral aspects ..	Side lying.

These various positions are modified by the anatomical and pathological considerations of each case.

In cases where lobectomy is indicated the following methods are adopted :

1. Pre-operative physiotherapy is given—

(1) To train the patient in breathing control, by teaching (*a*) Diaphragmatic breathing with abdominal contraction on expiration ; and (*b*) Expansion of the bases of the lungs, and especially localized expansion in all directions for the side for operation.

(2) To improve the mobility of chest, shoulder girdle and spine.

(3) To teach correct posture.

(4) To improve the vital capacity and general condition of the patient.

(5) To get the patient accustomed to the physiotherapist so that early contact can be established after the operation.

* See appendix for diagrams and detailed instruction, pages 428 and 429.

2. Post-operative cases are also treated by physiotherapy to encourage expansion of the remainder of the lung which has been operated upon. This is carried out almost immediately after the operation, with very short but frequent doses of exercise.

The technique of this treatment consists in careful neuro-muscular training to the affected side, so that the muscles of the ribs work against localized pressure. The patient's thoughts must concentrate deeply upon the action, so that what is practically a unilateral movement is achieved. As the ribs move more freely the remaining lobe or lobes will be drawn out to fill the chest, including the space left by the removal of the diseased lobe.

Post-operative pain may cause bad posture, so that posture must be attended to. Much can be done by a skilful arrangement of pillows, so that scoliosis will not occur. Other prophylactic treatment will be indicated to prevent stiffening of the joints; massage over the neck muscles is beneficial in assisting relaxation. Carefully graded movements of the shoulder and spine must be given; or self-assisted exercises can be arranged with the use of apparatus as described in Chapter XII under "Weightless Exercises, A(1) and A(2)." This form of treatment will be found very suitable, owing to the gentle grading of work that is possible with its use. It has been used recently with satisfactory results for certain difficult ward cases in the Emergency Medical Services hospitals and at a Sanatorium.

(1) **Pneumonectomy** is an operation usually performed for cancer and other growths, or for severe cases of bronchiectasis. One lung is completely removed; the patient will be very ill and needs handling with great care.

Pre-operative physiotherapy is given as for lobectomy. Breathing exercises being given especially to improve expansion in all directions of the lung that will remain. Also exercise for the mobility of the chest wall, so that rib expansion will be more possible subsequent to operation.

Post-operative physiotherapy will be directed to encouraging the remaining lung gradually to compensate for the loss of the absent lung, and careful muscle training is given to both sides of the thorax, so that the chest wall shall not sink in at any part.

The compensatory property of the good lung may be very great, after skilful operations and physiotherapy.

SOME POST-OPERATIVE CONDITIONS AND THEIR APPROPRIATE PHYSIOTHERAPY

By WINIFRED LINTON, M.C.S.P., Brompton Hospital, London.

(2) **Thoracoplasty** for pulmonary tuberculosis is performed in cases where a permanent collapse of the lung is required. The number of ribs resected will vary according to the position of the cavity in the lung.

If the lesion is situated in the apex of the upper lobe, resection of 4 to 5 ribs may produce the necessary collapse. If the whole upper lobe is involved 7 to 8 ribs are usually resected, whereas a total thoracoplasty necessitates the resection of 10 ribs.

" The extent of the operation in each case should be in accordance with the localization of the cavitation, so that the collapse becomes as effective, and at the same time as limited to the diseased part of the lung, as possible." (Carl Semb.)

The operation is usually carried out in one, two or three stages, though a fourth stage is sometimes necessary for a total thoracoplasty.

The intervals between the stages vary ; some surgeons prefer fortnightly intervals, though others allow three weeks. Much depends on the condition of the patient, and sometimes a longer period is necessary to enable the patient to regain sufficient strength for the next stage, or to allow a temperature to settle.

The operation involves important muscle structures. The incision starts close to the upper border of the scapula, between it and the spine. It continues down close to the vertebral border of the scapula, turning outward over the lower ribs. Therefore trapezius, latissimus dorsi and the rhomboids, among other muscles, are incised, and need careful pre- and post-operative treatment.

At the first stage the 1st rib is excised, most of the 2nd rib and part of the 3rd. The scaleni muscles are therefore detached from their origins and left free. Thus the balance of the neck is dis-

turbed, and it will be drawn over to the opposite side, causing a typical thoracoplasty deformity.

Deformities that Usually Occur unless Prevented (See Fig. 188)

(1) Deviation of the neck to the strong side and sometimes dropping forward of the head.

(2) A lateral lean of the body to the side of the operation.

(3) Bulging of the lower ribs on the side of the operation.

(4) The shoulder is often raised.

(5) An alteration in the hip level.

Fig. 188.

Treatment must be given to prevent Deformity Occurring

Muscle contraction must be prevented, especially of the pectorals, latissimus dorsi and the muscles controlling the movements of the neck.

Faulty positions must be guarded against from the first.

Full elevation of the arm and mobility of the shoulder girdle should be obtained between each stage.

To accomplish this :

(1) Give pre-operative treatment to the patient.

(2) Gain his confidence, and see that he has a full understanding of the treatment that will be required after the operation, so that he will wish to co-operate.

(3) Gain the interest and co-operation of the nurse in charge of the case, so that she will see the necessity of always leaving the patient in a corrected position when she settles him up.

(4) Start treatment as soon as possible after the operation.

Prior to Operation

Train the patient in correct posture.

Teach him the movements that will be required subsequent to operation, *i.e.* gleno-humeral movements, shoulder girdle movements, including especially active contraction of rhomboids, and movements of the neck, especially a lateral side-to-side movement and neck extension.

Instruct him in relaxation. This is essential when trying to regain movements limited by muscle contraction.

Train him in *gentle* diaphragmatic breathing with abdominal contraction on expiration.

Post-operative Treatment

After all stages treatment may be started early :

(1) *To relieve pain*, by careful, gentle, " loosening " massage to relax tense muscles.

(2) *To correct the patient's posture* and leave him so that the hips and shoulders are level. The shoulders in vertical alignment with the hips—the tendency is for the body to lean towards the side of operation.

The head and neck resting on the pillow, carefully corrected, or even with a slight lateral lean *towards* the side of operation, to counteract the strong pull of the opposing scaleni.

The pillows must be adjusted so that the patient's back is well supported, especially in the lower part, and with no pressure on the thoracoplasty area.

This correction of posture should be thoroughly understood by the nurse in charge of the case, so that she can help him maintain it, or correct it where necessary.

Active assisted and carefully resisted movements to the shoulder and shoulder girdle may be started early in an easy and gradually increasing range.

Fig. 189.

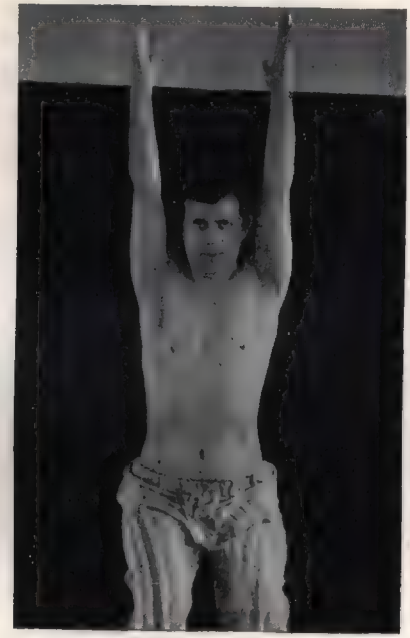

Fig. 190.

Shoulder girdle movements are of great importance. The movements required are :

(1) Raising and lowering—as the range of movement is often limited.
(2) Depression of the shoulder girdle, to counteract the frequently seen high shoulder after the operation.
(3) Backward movement of the shoulder girdle, to correct the usual forward displaced shoulder.

Elevation of the arm is gradually progressive. Any tendency of the lower ribs to bulge in a lateral direction whilst raising the

arm above shoulder level must be counteracted by pressure on the ribs. For the patient's own practice it is better for him to raise both arms together, thus giving an equal pull on the sides.

It is important to gain full range of movement after each stage.

The corrected position of the patient must be maintained during all movements, especially as regards the neck. This entails frequent pauses for correction during the treatment.

Early treatments must be short and nothing given to tire the patient. He must be left comfortable and *at rest.*

After the second stage great care must be taken in giving scapula movements. It is sometimes advisable to delay these movements till about the fifth day.

After the final stage careful graduated treatment is required, leading on to stronger postural exercises.

The patient should finally attain full range of arm and shoulder girdle movements, head, neck and spine in straight alignment, and a good posture (see Figs. 189 and 190).

EMPYEMA

By J. Reed, M.C.S.P., T.M.G., Harefield County Sanatorium, and Brompton Hospital, London.

In the majority of cases of empyema a surgical operation is necessary. This consists of resection of a piece of rib, followed by the opening of the base of the pus-containing cavity between the two layers of pleura. A tube is inserted and given under-water drainage to prevent the entrance of air before the patient leaves the operating theatre.

The physical treatment of empyema aims at securing full lung re-expansion. Necessarily the details of treatment will vary according to the condition of the patient in each case. Obviously the treatment after operation varies in length and intensity, but generally the ideal treatment should be of about 10 minutes two or three times a day, until the patient is fit enough to practise by himself, when daily periods of 20 minutes will usually suffice.

Before setting out the method of the treatment the importance of the teacher and the patient securing mutual co-operation must be emphasized ; both must concentrate their hardest on the work

in hand. The patient will gain increasing confidence by recognizing that the efficacy of the treatment largely depends upon his ability to control his breathing and chest movements.

The *aims of treatment* may be summarized as follows :

(1) Gain re-expansion of the lung as soon as possible, before the pleura has time to become thickened and hardened.

(2) Prevent from the earliest stages the onset of postural deformities which are extremely likely to occur in all but the mildest cases.

(3) Develop a habit of correct breathing and posture, progressively in half-lying position, sitting, standing and walking.

Generally the treatment consists of localized breathing exercises with the object of gaining chest expansion. It is most important that from the beginning the patient is made to realize that the goal he is seeking is full lung expansion, though on his journey he will also have to correct postural deformities.

Treatment is started 24 to 48 hours after operation, or within a few hours after the first aspiration in those cases not needing tube drainage.

The *method of treatment* in detail :

The first thing is to see that the pillows are adjusted to help maintain a correct posture. This is done by avoiding pressure against the dressing area, giving a free exit to the tube and support where needed to help the patient keep in a good position, while at the same time relaxed.

When moving the patient for posture-correction first make sure that the length of tube allows him to sit up. See that it is impossible for the tube or clip on it to catch against anything, and in placing the patient's back correctly against his pillows make sure that it is not kinked or pressing against bed-rest, etc. The distal end of the rubber tube is connected to a glass tube, the open end of which terminates under water in the drainage bottle. Slight negative pressure is maintained, so that water is always sucked up the glass tube, and this tube should be swinging freely with the patient's breathing.

The following are the usual *postural defects* (see Fig. 191) with which the physiotherapist has to deal :

(1) The hip of the affected side is raised and all weight is taken on the other hip.
(2) There is a lateral lean of the body away from the affected side.

FIG. 191.—Case of multiple lung abscess and empyema.

FIG. 192.—The end result.

(3) The shoulder on the affected side is lowered.
(4) The effect of the above is to cause a lumbo-dorsal curve of the spine with convexity to the sound side.
(5) The neck also develops a lateral lean, but towards the affected side, thus forming a compensatory curve to the dorsal one.
(6) The back as a whole tends to become kyphosed and shoulders rounded.

These postural deformities are naturally more common with severe and chronic cases, but need prevention in all.

Corrective active movements are localized to each bad point in turn. Mirrors are used, especially for shoulder, neck and head correction.

In some cases where there is muscle-spasm owing to pain, it is necessary to give massage and loosening movements to gain relaxation. It is surprising how quickly careful rhythmical kneadings and small relaxed movements will bring about relaxation.

Breathing exercises are given as soon as the patient is relaxed and his posture corrected. They are followed by progressive active assisted movements for shoulder, and shoulder girdle, and are repeated again after further breathing.

Breathing exercises consist of:

(1) Diaphragmatic breathing. This is always the first exercise taught to encourage good use of the large basal area of the lungs. Breathlessness is likely to be present with the acutely ill cases, and a shortened form of diaphragmatic breathing is given to counteract this, as well as the main slower exercise.

(2) Localized pressure expansion exercises for different areas: (*a*) Lateral basal expansion for both sides, and (*b*) for the affected side separately. In chronic cases, with excessive movement on the sound side and none on the affected side, both-sided expansion is delayed until the weak side can expand a little.

When expansion of the base of the lung is improving pressure is localized a little higher up for (*c*) expansion of the middle lobe area of the lung, and finally (as movement improves in this part) pressure is given for (*d*) expansion of the upper lobe area, applied just below the clavicle. In a chronic empyema it is often this area which is particularly weak, and therefore it must be exercised as soon as possible. For such cases pressure should also be given just below the axilla for outwards expansion of the upper lobe.

For all one-sided exercises the other side should be steadied in the corresponding area by the other hand. Posterior basal expansion is also practised, but is most successful when the patient is up.

Later treatment.—The active movements are usually quickly increased from assisted, to resisted, and then stronger free exercises, so that on starting to get up the patient's shoulder and shoulder girdle muscles are strong and movements are full in range.

As soon as the patient is allowed up lateral and forward-bending and raising trunk exercises are given in time with breathing, also further loosening, strengthening and postural exercises. After a week or so these exercises are given in graded classes, while individual training in breathing and posture continues until the patient is discharged.

Chest measurements and vital capacity tests are taken at regular intervals to gauge improvement and to encourage the patient.

Chapter XVI

REHABILITATION IN THE MATERNITY UNIT

PHYSIOTHERAPY AND THE PUERPERIUM

Introduction: By Beatrice Turner, F.R.C.S. Ed., F.R.C.O.G.

Introduction.—The purpose of all good midwifery should be to deliver the patient of a living, healthy child, and then to return the mother to a normal, useful life in as good, or—if possible—better condition than she was before her confinement.

The old days of white-faced invalids, with weak voices, lying flat in their beds for a month are, we hope, gone for good. They have been replaced by the happy, strong, vital young mother, ready at the end of 14 to 21 days to face anything that may be necessary.

It has been my opinion for many years that there are two ways of conducting the puerperium. In the first the patient, if she has time and money, and needs the rest, may lie in bed for three weeks to a month, but if she is to take this course, the muscle tone and function must be maintained by properly planned massage and exercises. The second method is to aim at keeping the patient in a condition of muscular tone that will enable her to rise and resume her duties in 10 to 14 days, and, if necessary, to be able to get up and walk at any time during the puerperium.

It is too often forgotten that the patient should go into labour a perfectly strong, healthy woman, and that the labour itself should only leave her tired in the same way as after a very hard day's work, or a strenuous game of hockey or tennis. It is the period of lying flaccid in bed, making no or few muscular movements, that produces the consequent weakness and inability to make an effort. I am speaking now of the normal labour and confinement.

The war has made the second method of treatment the most practical, because at any time it may be necessary to evacuate a

hospital. If patients are all able to get out of bed and walk with help, the time of evacuation can be halved, and they feel far more confident, and rest better at night, if they know that by their own efforts they are able to gain safety, and are not dependent on others. For this reason every patient in the Emergency Maternity Hospital where I am working gets out of bed and sits on a chair from the first day. All patients are given massage, and communal exercises are carried out to the tune of a gramophone. The objects of these exercises and massage are :

(1) *To restore normal function to those organs which have been affected by the pregnancy and labour.*

In this group the abdominal muscles, which may have been grossly overstretched, and the levator ani group of muscles are, of course, the most important. By restoring tone to these two groups the proper evacuation and control of the bladder and bowel is ensured, the " figure " of the patient is preserved, and puerperal backache is prevented. The restoration of the levator ani muscles is particularly important in the prevention of prolapse, and exercises should be instituted, even if there has been a rupture of the perineum. If this has been satisfactorily sutured the stitches will take no harm.

(2) *To prevent disuse atrophy and weakness of the muscles.*

This applies particularly to the limbs and back muscles, which should not have been affected by the pregnancy, but will easily become useless if not exercised.

(3) *To assist involution of the uterus and establishment of lactation.*

If the involution of the uterus is delayed this can be assisted by gentle daily massage of the fundus after the bladder has been emptied. Hot and cold sponging of the breasts, followed by massage, will often improve lactation, and will also relieve painful, engorged breasts.

(4) *The prevention of constipation, displacements, thrombosis.*

Early institution of general and abdominal massage and exercises will tone up the whole system ; the bowels will act more easily ; the small, well-involuted uterus will be less likely to become

retroverted (especially if the perineal muscles regain their tone rapidly) ; and lastly, the likelihood of thrombosis of leg or pelvic veins will be reduced if the stagnation of blood in flaccid limbs and engorged veins is guarded against.

I hope that I have made out a case for the early and regular use of massage and exercises in the puerperium. The details of such treatment in an effort to "rehabilitate" the puerperal woman I leave to Mrs. Guthrie-Smith, whose students have been giving the treatments in this war-time hospital.

Physiotherapy at a War-Time Maternity Hospital

By the Author

In the new surroundings of a large country house a fresh and invigorating atmosphere has been introduced to which the patients react in a most stimulating and satisfactory manner. The large bedrooms hold about six or eight patients, who stay in these hospitals as long as is necessary. In each ward, therefore, there may be some mothers who have been there ten days, whilst others have only just arrived from the labour ward.

To fall in with the modern spirit, and to encourage the cheerful atmosphere which is such a marked feature of this hospital, it was decided to carry out as much physiotherapy as possible by class work with music, so that all could take part. A team of students was accordingly sent to work under the general direction of Dr. Turner.

The very simplest and easiest exercises are selected, so that even the first day mothers can make a beginning when, after a few gentle movements, they rest and *watch* the exercises carried out by the remainder of the class. As the class proceeds, the second, third, and fourth day-mothers are told to "fall out," while the others complete the full scheme of exercises. In this way all share the mental stimulation of music and drill, and learn by observation what will be expected of them.

Owing to the difficulty of transport, and the distances to be covered, it was only possible to carry out physiotherapy three days a week at the hospital, so the patients are taught exercises which can be practised between the days of instruction ; and once they

understand what is required of them they have been found to be most co-operative.

From time to time a little talk or lecture is given to the mothers in each ward by the teacher in charge. The importance of retaining a good figure is stressed and the drawback of weak muscles is pointed out. The mothers are urged not to waste the opportunities offered to them of getting fit. After a talk of this sort one woman will usually show more interest than the others, whereupon she will be selected to be the "leader." In this capacity she can remind the others of the appropriate exercises to be practised, for periods of three minutes six times a day.

A certain responsibility is thus thrown on the patients, so that they can learn to rehabilitate themselves. A good habit of exercise, little and often, will be established.

The physiotherapist has a great opportunity as a teacher with this type of patient, and should instil much mental stimulation; if young women are properly instructed they are more likely to keep up their muscle tone and good posture after leaving hospital. For this reason only a very few but definite exercises are given, and the purposes for choosing them are carefully explained and discussed, until a clear understanding of the theory underlying the treatment is grasped. The clearer and simpler the instruction, the more satisfactory will be the result.

These women have a physical appreciation of their pelvic floor which is denied to other patients, and the necessity to tighten up their muscle tone is quite obvious to them. Once the method is understood they apply the knowledge well.

The physiotherapist student is warned that it is of the utmost importance to safeguard patients from infection, which may be carried into the building or to carry infection from one patient to another. It is necessary to keep special overalls in the wards and to take all possible care in "scrubbing up," also to wear face masks while on duty. Before treatment the patient's chart should be examined and the pulse and temperature noted.

The pulse rate may be somewhat slower than normal, 60 to 70 being the average.

Temperature.—Should remain normal. If it rises over 100 some infection may be feared, and the patient is usually isolated.

Urine.—May be retained. *Constipation* may be present. Both conditions may be due to a lax abdominal wall.

The remedial exercises chosen are classified under the headings of their *utility*, and then arranged in a progressive scheme. The principles underlying the exercises must be thoroughly understood by the physiotherapist before the classes are begun.

(1) **To assist drainage and involution.**—All the patients sit up from the first day, all are given breathing exercises, and are encouraged to contract the abdominal wall. Each patient is ordered finger-tip moulding over the uterus—a localized, gentle but definite manipulation to assist involution. After a few days this is discontinued, as the purpose is fulfilled. Should there be constipation or indigestion, other and appropriate forms of abdominal massage are employed. A little gentle kneading of the lumbar area is much liked and prevents backache. Lateral stroking manipulations of the abdominal wall so as to draw it inwards, greatly assists in restoring the figure. All the "first-day" mothers are got out of bed by the nursing staff for a few moments as a precautionary measure, in view of possible air-raid evacuation; and during their afternoon sleep they lie in the prone position from the first. All these manipulations and postures assist the drainage of lochia, and the involution of the uterus.

Uterus.—After delivery the uterus involutes very quickly. At this period it is $4\frac{3}{4}$ in. above the symphysis pubis, and can be palpated as a hard mass. Measurements at this time are: *Length,* 7 to 8 in.; *cavity,* $6\frac{3}{4}$ in.; *muscle walls* vary from 2 in. to $\frac{1}{4}$ in. at different parts; *weight,* 32 oz. After seven days the measurements are: *Length,* 5 in.; *weight,* 16 oz., and it is $3\frac{3}{4}$ in. above the pubis. After twelve days it is $1\frac{1}{4}$ in. above the pubis. On the fourteenth day the uterus is below the symphysis pubis.

Lochia is discharged after delivery; the amount and type of the discharge should be studied in connection with the physical treatment.

(2) **Lactation.**—One or two days after the birth no milk is found, but a fluid, "colostrum," is secreted. On the third day the breasts may become very tender and painful, even knotted. Hot fomentations, gentle massage with oil, soap and water will give great relief and promote natural lactation.

The nipples may crack, and must be treated. If they are neglected bacteria may invade the gland and cause *acute mastitis.* This condition is a *contra-indication* for massage, as an abscess may form which may need opening.

Certain patients are ordered massage to the breast (with soap and water and oil) in order to assist lactation ; the whole area of the chest from the clavicle to the axilla, and the whole length of the sternum to the axilla is gently effleuraged by circular stroking towards the nipple. Tension within the gland is thus relieved, and the patients appreciate the treatment.

Arm exercises which use the pectoralis major in flexion and adduction are useful in relieving tension in the area of the mammary gland. The movements are combined in actions such as are used when throwing a ball. Arm extension movements to stretch the pectorals should also be included.

(3) **The pelvic floor.**—The most important exercises are those that succeed in obtaining contraction of the muscles of the pelvic floor. One method of achieving this is to grip a small book between the knees ; then to direct the patient to contract the adductor muscles, inch by inch, from the knee to the perineum ; then to contract the glutei while still holding the former muscles tense ; finally to draw in the lower part of the abdominal wall. Relaxation follows and the exercise is repeated. At first this muscle control must be learnt little by little, but once the technique is mastered it is one she will not easily forget.

The pelvic floor can also be contracted and lifted up with synergic action of the gluteus maximus ; this is a useful exercise to carry out in a sitting position. The pelvic floor is also worked in conjunction with the external rotator muscles of the hip. These muscles, the pyriformis and obturators, are said to be unusually weak in English women, in contrast to hill-climbing nationalities. As this muscle group is situated *inside* the pelvis it should be considered as of special importance with regard to pelvic conditions and strengthened accordingly.

It is undesirable in the early stages to give exercises which part the legs, and put the perineum on the stretch.

Perineal lacerations are sutured and heal like all other parts of the body in about 10 to 14 days. Severe tears must on no account

be subjected to strain during physiotherapy, though certain "tensing" exercises will be of benefit.

Several days should be allowed to pass, so that any tearing of the perineum will not occur. Stitches must have time to heal. Therefore all vigorous leg exercises are best postponed until the patient has been in bed about seven days.

(4) **Abdominal wall.**—It is as well to explain carefully the shape and function of the "transversalis." This belt-like muscle directly supports the viscera, and should be clearly visualized by the patient, who will learn to compress the viscera by constricting the muscle. Next, the mother must be instructed to work this muscle in conjunction with the gluteus maximus, so as to *retract* the abdomen. The effect is directly on the viscera, moving them and raising the intra-abdominal pressure—a very important factor for health and the proper functioning of the circulation and abdominal organs (Fig. 88).

The *rectus abdominus* comes into play and is easily felt by patients when performing head-raising or leg-raising exercises. A very strong exercise can be obtained by putting both sets of muscles, the recti and the hip flexors, into action at the same time. This is done by placing the head and knees in contact while the back is arched like a rocking-horse ; the hands hold below the knees (Fig. 89, "Regional Exercises").

The oblique muscles are brought into play by rolling the shoulders and upper trunk over in bed, while the operator holds the pelvis in a straight line ; conversely, if the shoulders are fixed by the operator, the pelvis is rotated and the legs thrown across each other, first to one side then to the other from this fixed point.

The lateral straight fibres of the abdominal and back muscles can be worked to a maximum by combining side flexion of the trunk with leg abduction. Either one or the other group of muscles can be worked singly (Fig. 97, "Regional Exercises").

(5) **The posterior abdominal wall.**—Lumbar pain and stiffness must be prevented ; the mother is encouraged to lie on the side and tilt the pelvis to mobilize the lumbar spine, and to repeat this exercise in all other possible positions, excluding the supine position.

(6) **Retroversion of the uterus.**—This complication is not so likely to occur if the patient can regain as quickly as possible the tone of the pelvic-floor muscles. However, in order to make doubly sure, many exercises can and should be carried out in "the knee-chest" position. The patient, having assumed the position, proceeds to carry out pelvic tilting, pelvic side flexions, and abdominal contractions with deep breathing. The head should be turned first to one side and then to the other, in order to avoid any stiffness in the neck.

Retroversion and acute anteversion are both abnormal positions of the uterus.

The normal position is about 90 degrees or a right angle with the vagina.

(7) **Breathing exercises.**—All types of breathing exercises are indicated, and should be interspersed between other exercises. Their value in the prevention of thrombus formation, and their use as a means of teaching relaxation, have been fully dealt with in other chapters. For abdominal conditions their expiratory action has great value in aiding normal drainage, normal functioning of the gut and involution of the uterus.

(8) **Massage.**—Massage to the arms is usually unnecessary. Dr. Turner advocates massage for the legs as the circulation is promoted, and the formation of thrombi tends to be prevented.

A SCHEME OF EXERCISE

1st and 2nd days. General relaxation should be taught in order to eliminate faulty posture while lying in bed.

(1) Toe clawing with dorsi and plantar flexions and tensing of quadriceps.
(2) Breathing with abdominal contractions on expiration.
(3) Feet crossed, ankle rolling.
(4) Breathing, lower costal type, with hands on ribs. Self resisted.
(5) Adduction of knees and thighs, holding book, working adductors inch by inch, as already explained from knee to pelvic floor.

3rd and 4th days. Same as first two days, and add:

(6) Arm-raising sideways, and breathing.
(7) Lying head raising to contract abdominal wall.
(8) Prone-lying breathing in—out with abdominal contractions (chiefly transversalis).

(9) Side-lying pelvic tilting.
(10) Knee adduction continued as in No. 5.

1st, 2nd, 3rd, 4th days. Finger-tip massage to the uterus helps drainage; also a little back massage with fingers round lumbar spine reduces any backache. Leg massage—foot to mid-thigh region improves the circulation.

5th and 6th days. Same as first two days, and add:

(6) "Ball throwing," bringing arm forward.
(7) Prone-lying head and shoulder raising for toning up the upper back muscles.
(8) Breathing—lower costal expansion with abdominal contractions on breathing out.
(9) Knee chest position: (*a*) Pelvic tilting (donkey); (*b*) pelvic side flexions.
(10) Heave grasp, holding top of bed—leg crossing.
(11) Sitting—shoulder rolling.
(12) Crook-lying pelvis raised, contracting adductors, abdominal, gluteal and pelvic muscles.
(13) Arms crossed on chest—head and shoulder raising with foot support.

7th, 8th and 9th days. Same as first two days, and add:

(6) Ball throwing with trunk rotations, fairly vigorous.
(7) Prone-lying head and shoulder raising.
(8) Prone-lying breathing with abdominal contractions on breathing out.
(9) Knee-chest position—pelvic tilting, pelvic side flexion and abdominal contraction.
(10) Heave grasp, leg crossing—lower abdominal rotation.
(11) Crook-lying—knee raising on to chest with head and shoulder raising progressing to double knee raising.
(12) Breathing in all parts of the thorax.
(13) Crook-lying, pelvis raised, rotations of trunk and tilting of pelvis.
(14) Lax kneeling, uncurling the spine vertebra by vertebra, ending with strong extension of head and spine.

After 10 *days.* Posture training is now the most important consideration.

(1) Patient stands in a slack posture, tightens all muscles with rippling movement upwards.
(2) Posture drill, stretching whole body, adding arm movements.
(3) Alternate knee raising: (*a*) Sitting; (*b*) standing.
(4) Knee-chest position pelvic exercises.
(5) Ball throwing in standing with trunk rotations picking up ball from floor.
(6) General posture correction. Back raising vertebra by vertebra.

(7) Pelvic tilting in sitting and standing.
(8) Trunk side flexions.
(9) Sitting. Crossing legs while maintaining good posture.
(10) Stride standing—arm rolling and breathing.

SUMMARY

Lactation	Pelvic Floor	Abdominal Wall	Lumbar Spine	Retroversion	Breathing	Massage
Breast massage. Repletive or Depletive exercises as found necessary.	Synergic muscle work of Adductors and : 1. Levator ani. 2. Glutei and levator ani. 3. External rotators of hip and levator ani.	Abdominal Retraction, Contraction, Side flexion, Rotation. Leg movements involving hip flexiors.	Pelvic tilting in *all* positions. Knee-chest positions.	Knee-chest position. All such exercises in this position, as pelvic tilting side flexion of the pelvis. Abdominal contraction, prone lying.	Natural breathing with arm movements with Abdominal contraction on the outgoing breath.	Abdominal, region over area of uterus. Lumbar region. Lower limb. Upper limb.

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CHAPTER XVII

REHABILITATION BY GAMES

THE PLACE OF HEAVY BALL EXERCISES IN REHABILITATION

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Drawings by BARBARA HENDERSON

"Gymnastic" is a term taken from the old Greek language and it is commonly used in modern times to indicate various types of physical exercise. From ancient representations of gymnastics one common factor emerges, that of unity of expression throughout the whole personality. A type of movement is portrayed which is not only exercise but also involves feelings of joy and sorrow. This is an essential point which during the last one hundred and fifty years has been sadly neglected. A human being is not a machine with an intricate system of levers which are moved by cords running over pulleys. An essential point is omitted if living structure is considered only from a mechanical or anatomical point of view. Such a consideration leaves out the spark which makes it alive. To consider movement from the same aspect is equally wrong. The movements of a small child shows what an essential part "joy" plays in this expression of life. Joy is just as important as the movement itself. It is universally recognized what an important part is played by influencing all organic functions, through joy as a stimulator or boredom as a depressor. It is therefore essential to consider these factors when planning gymnastic movement for remedial purposes; it is then doubly valuable. The remedial aim, be it mobility or restoration of muscle strength, must stand clearly before the mind; but the exercises chosen must be enjoyable in order to pave the way to quicker recovery.

There are certain pieces of apparatus which have a universal appeal to the "play instinct" in mankind, and the ball is one of the most popular. Ball gymnastics distract the attention from personal ailments and concentrates the mind on outside objects.

It is for the gymnast to convert this object into a specialized form of remedial treatment.

Effects of Heavy Ball Exercises

Active movement results in strengthening the working muscles. This strengthening process may work in two directions according to the type of work demanded from the muscles.

Muscle power can be used to overcome resistance ;
To produce swinging rhythmical movement.

The first type of movement will build large muscle masses, the latter will affect chiefly :

(1) The mobility of joints ;
(2) The co-ordination of large groups of muscles ;
(3) The capacity to work for long periods.

According to this classification of muscular function, heavy ball exercises can help to restore function in two main directions :

I. Strengthen weakened muscles or hypertrophy muscles which will have to take on for longer or shorter periods an increased function ; for instance, in the treatment of compression fractures of the spine, the longitudinal back muscles.

II. Restore muscular rhythm, co-ordination or mobility.

Choice of Exercises

The strengthening effect can be achieved in three ways, and exercises have to be graduated accordingly. One progression is to increase the resistance to be overcome by increasing the weight of the ball ; the second to increase the speed of the contraction ; and the third to increase the intensity of the contraction by putting more force behind it. All living tissues adapts itself within certain limits to its function. Muscular tissue which has to overcome great resistance during its working periods will increase in muscle bulk, while muscle tissue which has to work for long periods will usually decrease in bulk. This adaptation takes place within the limits of certain hereditary factors. Muscle bulk is the decisive factor in relation to muscle tone, apart from certain sympathetic

influences. Tone represents the passive power of resistance of muscle tissue towards stretching influences during periods of rest. The importance of this fact cannot be overstressed in regard to treatments when muscle power is the essential aim. Unless muscular tissue is used beyond a certain threshold no stimulus of growth in diameter or muscle bulk is given and consequently no rise in permanent muscle tone takes place. The adaptation to work for long periods takes place by more efficient elimination of products of fatigue, which is usually accompanied by a decrease in the permanent muscle tone. For conditions such as spinal deformities, certain knee injuries, and many others where increase in muscle power is essential, remedial work, which does not take these factors of adaptation into account, may be definitely harmful.

Group I. Strengthening Exercises (Figs. 193 to 196)

EXAMPLES OF EXERCISES, MAINLY USING THE ARM AND SHOULDER MUSCLES AND THEIR FIXATORS

(Fig. 193.) (1) *Double arm across bend stride standing* (elbows at shoulder level) (1*a*).

(*a*) Push the ball forward and release it (1*b*). The ball is returned by a partner.

(*b*) Push the ball upward and release it (1*c*).

(2) *Across bend R(L) stride, turn standing.* Push ball forward and release from R(L) hand.

(Fig. 194.) (3) *R(L) bend stride standing, elbow adducted* (3*a*). Push ball upward and release it (3*b*).

The number beneath the diagram relates to the number of the exercise in the text.

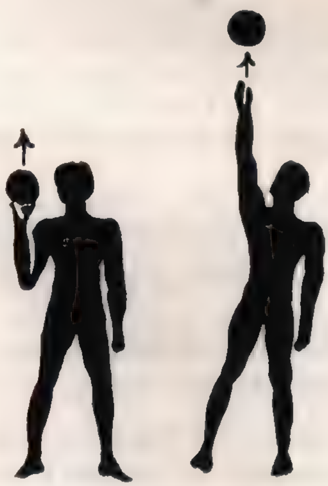
EXAMPLES OF EXERCISES, MAINLY USING THE TRUNK ROTATORS

(Fig. 195.) (4) *R(L) trunk turn lax stoop stride standing, weight on R(L) leg* (4*a*). Ball rests against R(L) forearm and flexed wrist, secured by fingers. A quick turning to the left (right) with transfer of weight to left (right) leg, releases the ball (4*b*).

Unless a one-sided lesion is treated, the exercise must be practised on both sides, as the effect on the rotators on the back is very powerful.

1a. 1b. 1c

FIG. 193, 1a, 1b, 1c.



3a. 3b.

FIG. 194, 3a, 3b.

4a. 4b.

FIG. 195, 4a, 4b.

Examples of Exercises mainly using the Back and Hip Extensors

(Fig. 196.) (5) *Lax stoop stride standing, ball grasped between two hands* (5*a*).

(*a*) Swing ball forward and upward with straight arms and release behind head (5*b*).

5*a*. 5*b*. 5*c*.

Fig. 196, 5*a*, 5*b*, 5*c*.

(*b*) Draw ball up along body, flexing elbows, to shoulder level, and push upward (5*c*).

A firm stance must be taken in all exercises. The exercises can be practised in an open space or against a firm wall.

Group II. Exercises to Restore Mobility, Rhythm and Co-ordination (Figs. 197 to 203)

The object in this group of exercises is to set the ball into motion in a certain way. Once moving, the ball obeys the natural laws of gravity and pendulum swing, resulting in a rhythmical movement. The human body becomes one with the ball through the holding

action of hands, wrists and forearms, and learns to take up the harmonious movement of the ball in motion. It is therefore essential in all exercises *that the flight of the ball should not be broken and the body be made to join into the described arc.* Attention is focussed on the ball and this fact helps to relieve protective muscular spasm, especially if it is caused only by apprehension. These exercises are therefore specially valuable in all cases of faulty innervation, lack of mobility, such as treatment after spinal fractures, when the plaster jacket has been removed, muscular contractures such as occur in certain types of sciatic scoliosis. Apart from traumatic injuries these exercises are also most helpful in the treatment of lung conditions, such as asthma, chronic bronchitis, etc., when the mobilization of the thorax is important, and abdominal conditions, such as constipation, especially the spastic type. Exercises can be easily made up to suit special conditions.

Exercises, mainly Working Muscles over Shoulder Joint and Shoulder Girdle

(Fig. 197.) (6) *Stride standing, ball grasped between two hands in front* (6*a*).

(*a*) Swing ball from side to side (6*b* and 6*c*).
(*b*) Same, but complete overhead circle on each third swing.
(*c*) Swing ball from side to side, throw it up alternate sides, and recatch it on falling curve.

(Fig. 198.) (7) *R*(*L*) *walk standing, ball resting against R*(*L*) *hand, arm outwardly rotating* (7*a*).

(*a*) Swing ball forward and backward (7*b*).
(*b*) Same, but release ball at top of forward swing and recatch on falling curve.
(*c*) Same as (*a*), but throw ball with under-arm swing to partner, who catches it on the downward curve.

(Fig. 199.) (8) *Lax stoop stride standing, ball between two hands* (8*a*). (Adapt stoop position to localize movement to desired region.)

(*a*) Swing ball from side to side with easy trunk movement (8*b* and 8*c*).

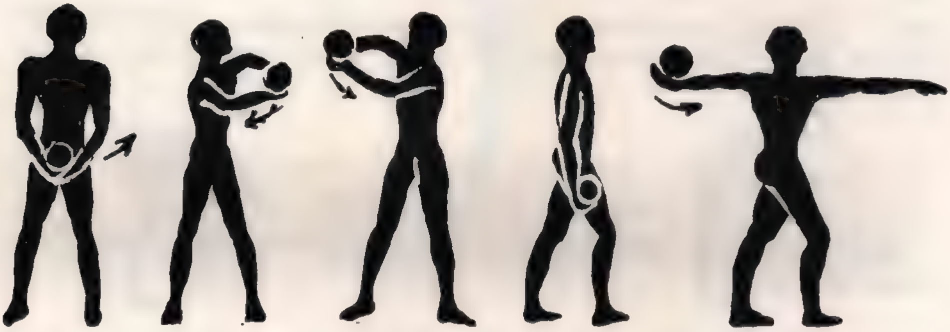
(*b*) Same, but release ball at top of swing, alternate sides, and recatch on downward curve.

(*c*) Same as (*a*), but add full circle overhead with complete stretch up on each third swing.

(Fig. 200.) (9) *Lax stoop stride standing, ball resting against R(L) hand* (9*a*).

(*a*) Swing ball from side to side with easy trunk movement.

(*b*) Same, but release ball at top of R(L) swing and recover it with under-arm grip, letting trunk join into movement of ball.



6*a*. 6*b*. 6*c*. 7*a*. 7*b*.

FIG. 197, 6*a*, 6*b*, 6*c*. Fig. 198, 7*a*, 7*b*.

(*c*) Same as (*b*), but release ball at top of L(R) swing and recover with other arm (9*b*).

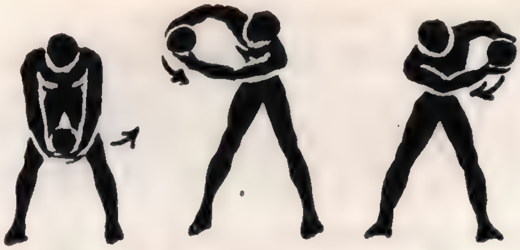
EXERCISES, MAINLY WORKING TRUNK SIDE FLEXORS

(Fig. 201.) (10) *Yard stride standing (palm facing upward), ball resting on R(L) hand* (10*a*).

(*a*) Throw ball over head from right and left hand, describing a semicircle (10*b*).

(*b*) Same, but catch as near the ground as possible (a slight rebound in the arm facilitates continuity).

(*c*) Same as (*a*), but throw ball in larger arc and move sideways to catch.



8*a*. 8*b*. 8*c*.

FIG. 199, 8*a*, 8*b*, 8*c*.

9*a*. 9*b*.

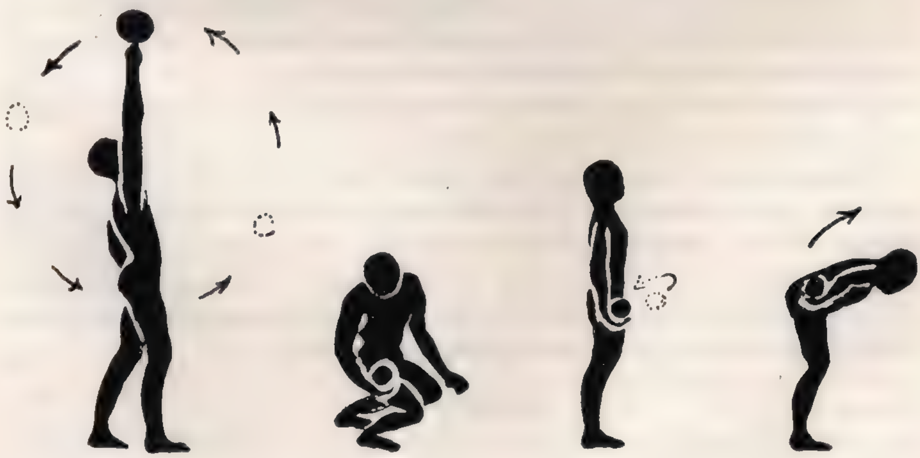
FIG. 200, 9*a*, 9*b*.

10*a*. 10*b*.

FIG. 201, 10*a*, 10*b*.

11*a*. 11*b*.

FIG. 202, 11*a*, 11*b*.



12*a*. 12*b*. 12*c*. 12*d*.

FIG. 203, 12*a*, 12*b*, 12*c*, 12*d*.

Combined Shoulder and Trunk Exercises

(Fig. 202.) (11) *Stride standing, arm outwardly rotated, ball resting in one hand.*

(*a*) Swing ball forward and backward ; at top of forward swing release ball and catch with other hand, without stopping flight of ball (11*a*).

(*b*) Same, but release ball at top of backward swing and recover with same hand (11*b*).

(Fig. 203.) (12) *R*(*L*) *walk standing, ball resting against R*(*L*) *hand.*

(*a*) Swing ball forward and backward ; at next forward swing complete full circle backward, letting the finger-tips run easily over the surface of the ball and let trunk join into movement of ball (12*a* and 12*b*).

(*b*) Swing ball forward and backward ; at top of backward swing describe an inward curve with the arm and release the ball backward, and recover it on its forward flight (12*c* and 12*d*).

This exercise can be done in stride standing and the ball caught at alternate sides.

The ball. Balls weighing 2 lb. or 4 lb. are specially made for these exercises.—A starting weight of 2 lb. is suitable (to be reduced for young children), which should be increased for Group I exercises according to age, sex, and type of patient. For Group II balls heavier than 2 lb. should not be used.

Suitable balls are made by most manufacturers of sports apparatus and by big rubber firms.

Precautions.—Care must be taken that the ball does not hit persons or apparatus. The ball must not be caught against the body. When catching is attempted in the exercises of Group I fingers must not be kept rigid, as this easily results in subluxation of the interphalangeal joints or stubbing of the articular cartilage. Balls heavier than 4 lb. should not be caught.

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Handbook of Remedial Gymnastics, by Dr. E. Matthias, Zurich.

Chapter XVIII

REHABILITATION IN THE GYMNASIUM: SOME STRONG EXERCISES SUITABLE FOR REHABILITATION OF PATIENTS AS INDIVIDUALS OR GROUPS

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INTRODUCTION

Restoration of function is the aim of all physiotherapeutic treatment. In order that a man may successfully return to full work in mine, forge, foundry, or other heavy trade, he should be able to perform a series of exercises which will work his muscles more strongly than he will need for his employment.

For the patient to progress, he must be worked each day to a pleasant point of fatigue. Strong exercises are often insufficiently stressed in the training of women physiotherapists, and it is to overcome this deficiency that the following exercises have been collected. Exercises given to men must often be far stronger than can be performed by even an athletic woman. The differences in muscle power and heart capacity in men and women is insufficiently taught and understood.

The following selection of exercises, which are suitable for any equipped gymnasium, are grouped according to their main muscle-work. Alternative starting positions will suggest themselves, but for the sake of brevity only representative exercises of each group are described. It is hoped that by using these outlines as a guide, exercises will be adapted to the needs of the patient. They may be used both in individual and group treatments, and many as home exercises.

The exercises are designed mainly to increase joint mobility and muscle tone. A good deal of static or isometric muscle-work is used, as muscles must both perform movements and hold positions. Altered speed of an exercise will alter the effect. Increased speed usually increases mobility whereas exercises taken slowly and followed by a static holding will increase muscle power.

Somersaults and vaults, or any exercise needing support, should never be given by women physiotherapists to men patients. They should only be used in women's gymnastics by qualified educational gymnasts who are trained in correct methods of support.

Weight-and-pulley exercises which need special apparatus are not included in this series. Many of the back exercises will increase the normal lumbar curve, but no harm will result if they are followed immediately afterwards by a lordosis correction which will also act as a relief exercise. Quite a lot of patients have obliteration of the normal lumbar convexity forwards, and this has to be corrected. In most cases the arch position should not be taken from crook- or crosswise-sitting because this position fixes the lumbar spine. The bend is taken strongly above, and the weakest part of the spine, the dorso-lumbar region, will be strained.

EXERCISES TO INNERVATE STRONGLY THE BACK MUSCLES

Fig. 204 represents the clasp position used when the shoulders are held forcibly retracted. If the wrists are kept at right angles the shoulders are easily pulled downwards as well as backwards.

FIG. 204.

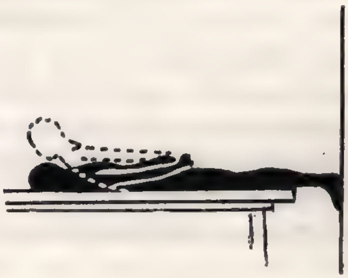


FIG. 205.

FIG. 206.

(1) *Hand clasp behind, foot fix, forward lying*; *back raising* (Fig. 205).—The weight-bearing surfaces of the feet must be kept pressed to the wall behind the patient during the whole exercise. This stimulates the postural reflex, causing a marked improvement of posture.

(2) *Wing, slack stoop leg forward lying; change to stretch arch leg forward lying* (Fig. 206).—The arms must change from wing through bend to stretch in a smooth movement as the trunk uncurls. Full flexion of the trunk is easier if the arms are started in wing.

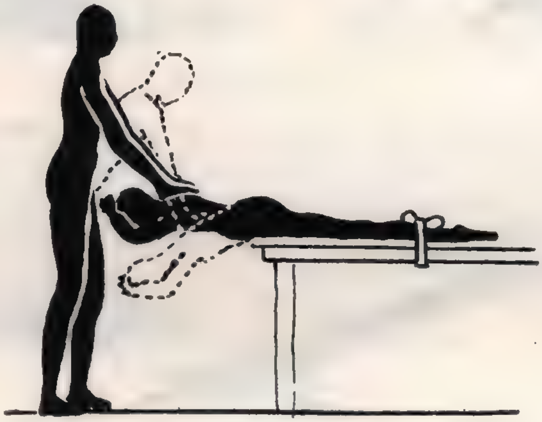


FIG. 207.

(3) *Head rest, leg forward lying; trunk downward pressing and raising* (Fig. 207).

(4) *Stretch, forward lying (over a stool) with feet supported; trunk forward bending and raising* (Fig. 208).

FIG. 208.

(5) *Hand clasp behind, slack stoop knee sitting; change to hand clasp behind, stoop knee sitting* (Fig. 209).—By flexion of the hips in the stoop knee sitting position the exercise is localized to the dorsal spine. To obtain the maximum movement in the slack stoop knee sitting the head must be drawn on to the thighs as near the hips as possible.

A

B

Fig. 209, A and B.

(6) *Stretch stoop kneeling; alternate leg lifting backwards* (Fig. 210).—The exercise can be taken either as a leg lifting or the lifting may be performed as the patient crawls forward. Prone kneeling with elbows bent may be used as an alternative starting position.

Fig. 210.

(7) *Prone kneeling; alternate arm, and leg lifting backwards* (Fig. 211).

Fig. 211.

(8) *Stretch front support (at wall bars) crosswise sitting; alternate, or double arm flinging backwards* (Fig. 212).—This is also useful in stretch front support kneeling.

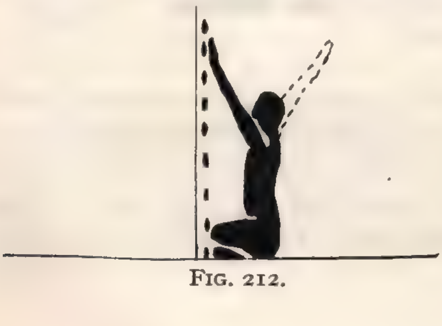


Fig. 212.

Fig. 213.

(9) *Wing knee stride sitting; trunk backward bending, and raising* (Fig. 213).

Fig. 214, A and B.

(10) *Arms crossed on chest, crook lying; trunk and shoulders raising and lowering* (Fig. 214).—To ensure a good lift on feet and head in Exercises 10, 11, 12 a firm pillow must be placed under the head.

Fig. 215, A and B.

(11) *Arms crossed on chest, lying; trunk and shoulders raising, and lowering* (Fig. 215).

Fig. 216, A and B.

(12) *Wing sitting, (between two forms) with head and feet supported; trunk raising and lowering* (Fig. 216).

(13) *Arch forward lying, grasping bent knees; holding* (Fig. 217).

Fig. 217.

Fig. 218.

(14) *Stretch, forward lying with knees flexed; trunk arching and holding* (Fig. 218).

(15) *Slack stoop standing; lifting heavy medicine ball and holding in stretch standing* (Fig. 219).—Medicine balls weighing up to 20 lb. can be used to combine exercises for arms and back muscles.

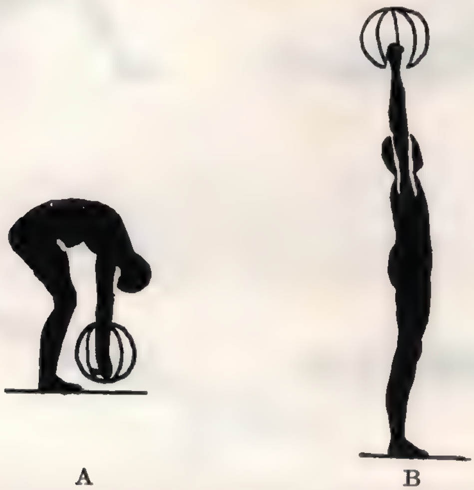


FIG. 219, A and B.

(16) *Span bending exercises.*—The choice of starting position for any of these exercises depends on the effect to be obtained and the strength of the patient.

FIG. 220.

(17) *Balance hanging on the boom; holding* (Fig. 220).

ARM EXERCISES

Group 1. General arm exercises.—All arm bendings and stretchings, flingings and swingings can be performed with clenched fists or sandbags of varying weights. These bags are a useful resistance and add force to pendulum swings, thereby increasing movement. The bags should not be filled too firmly, so that the hands can easily grasp them without slipping. In men's exercises two 5-lb. bags are a useful weight. Ordinary or spring dumb-bells may be used instead. Exercises with Indian clubs assist movement in wrists, elbows and shoulders. Arm rotations can be resisted with rods or pokers.

Crook or half crook sitting, knee sitting, or half knee sitting with one leg stretched sideways, ride sitting or lunge standing are all useful starting positions for arm exercises.

FIG. 221.

Group 2. Exercises to work flexor groups and adductors of shoulders.—All heaving exercises at booms and wall-bars with straight or bent arms. These can be combined with simple leg exercises such as swingings, bending of hips and knees, or bicycling. Heaves through window-ladders or double booms or double ropes are also useful.

Heave hanging, alternate knee raising (Fig. 221).—Fall hanging or arch-hanging heaving and sinking have also their uses.

Group 3. Exercises to work mainly extensors of arms and serratus magnus.

(1) *Prone falling; elbow bending and stretching* (see "Leg Exercises," Fig. 228).

(2) *High front support (on form) prone falling; elbow bending and stretching.*—This can later be combined with alternate leg lifting backwards (Fig. 222).

(3) *High foot support (form, boom or wall bars) prone falling; elbow bending and stretching* (Fig. 223).

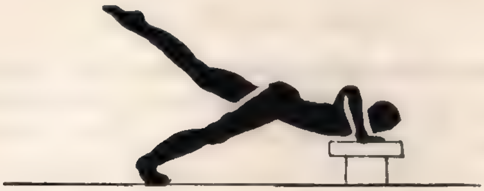


FIG. 222.

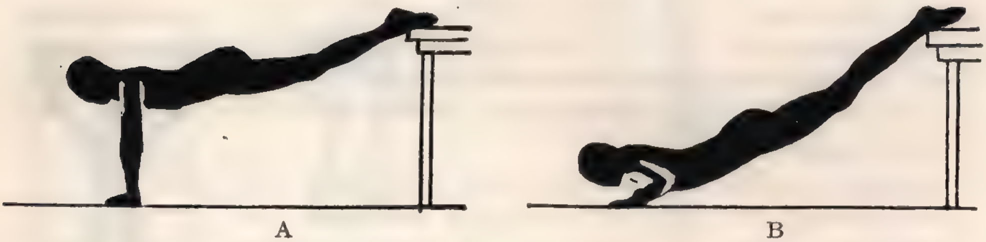


FIG. 223, A and B.

(4) *Hand standing (against wall-bars), elbow bending and stretching.*

(5) *Punch ball practice.*—Floor-and-ceiling type is useful, as it is easily removed and can be used in a smaller space than the floor type. Boxing gloves are not essential, ordinary leather ones being quite adequate.

(6) *Throwing exercises*, with medicine balls of varying weights, may be used in this group of exercises (see " Back Exercises," Fig. 219).

LEG EXERCISES

To exercise the leg muscles various leg swingings, bendings and stretchings, stepping on and off boxes, forms, etc., will be used. Skipping is a very valuable general activity exercise ; the movements of bicycling can be done in lying or hanging.

(1) *Lying ; bicycling, with the hands supporting the lumbar spine* (Fig. 224).—The hands are placed on the floor, palms downwards, under the lumbar spine. This fixes the trunk slightly, raises the pelvis, and allows greater activity.

(2) *Standing ; heels raise and knees bend.*

FIG. 224.

(3) *Knee sitting ; trunk raising and lowering.*—These exercises (2) and (3) can be resisted if the patient holds sandbags of varying weights in the hands (see "Arm Exercises," Group 1).

(4) *Stretch grasp, front support standing ; double leg swinging backwards* (Fig. 225).

(5) *Stretch horizontal half standing ; holding* (Fig. 226).

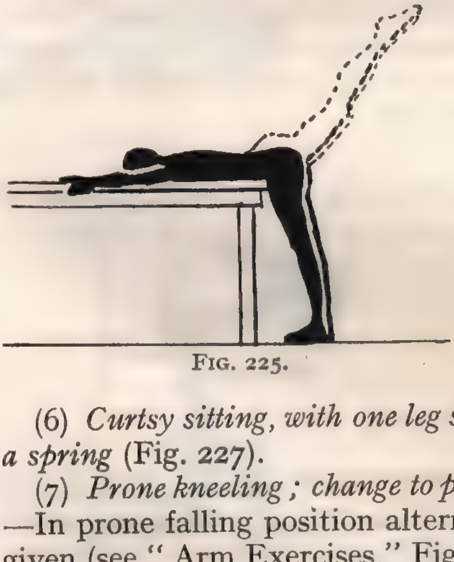


FIG. 225.

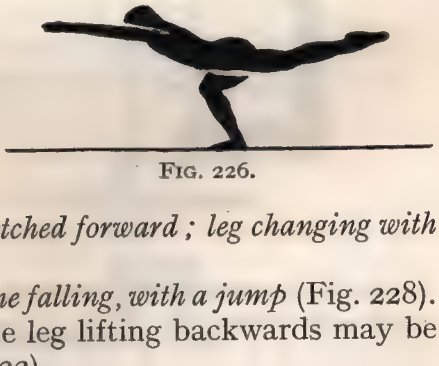


FIG. 226.

(6) *Curtsy sitting, with one leg stretched forward ; leg changing with a spring* (Fig. 227).

(7) *Prone kneeling ; change to prone falling, with a jump* (Fig. 228). —In prone falling position alternate leg lifting backwards may be given (see "Arm Exercises," Fig. 222).

A B

FIG. 227, A and B.

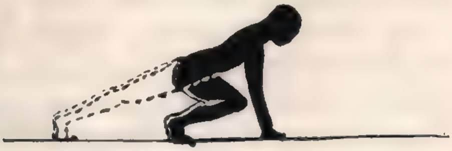
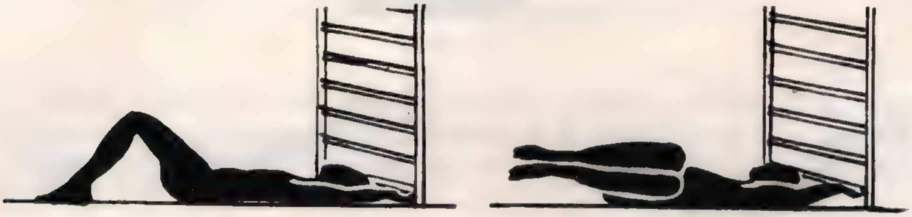


FIG. 228.

TRUNK ROTATION EXERCISES

Group 1. Movement obtained by using the legs.

(1) *Heave grasp, crook lying; double knee rolling* (Fig. 229).—This can be progressed if performed on the high plinth, the knees being



A B

FIG. 229, A and B.

rolled to each side of the narrow end so obtaining greater rotation. A second progression is from hanging with back against wall-bars.

(2) *Heave grasp lying (with straight legs raised to right angles); leg lowering to alternate sides* (Fig. 230).

A B

FIG. 230, A and B.

(3) *Heave grasp lying; trunk rotated to right, left knee bent as near right arm as possible.*—Draw right knee along the floor from under left one, and then bring it over to rotate trunk to the left and repeat drawing up left leg along the floor (Fig. 231). Progressed by starting in yard-lying with palms touching the floor.

(4) *Neck rest lying; trunk flexion* with trunk rotation to left, combined right pelvic rotation and left knee flexion to touch outer side of right forearm as near axilla as possible. Stretch out and then change to opposite sides. During this exercise the elbow to which the knee is being flexed is brought forward (Fig. 232).

(5) *Stretch grasp, high lying with toes supported; double leg lifting and swinging to alternate sides to touch the floor.*—A pillow must be placed under the sacrum (Fig. 233).

A B

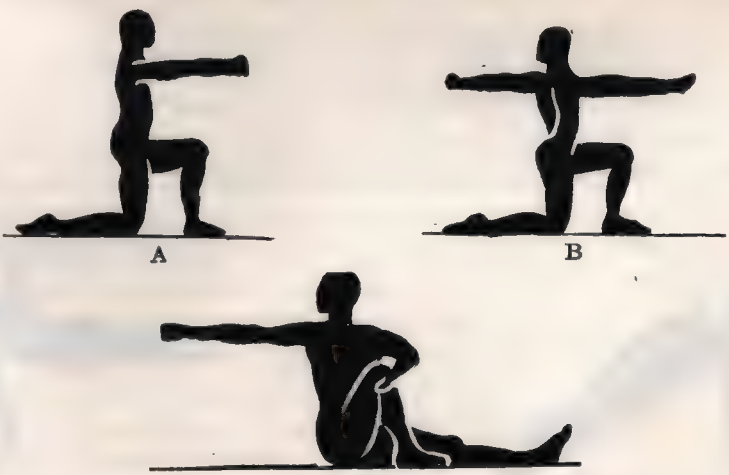
FIG. 231, A and B.

FIG. 232.

FIG. 233.

Group 2. Movement obtained by using the arms.

(1) *Reach (with fists touching) half knee standing; trunk rotation with arm swinging* (Fig. 234).—The flexed hip fixes the pelvis and



A B C

FIG. 234, A, B and C.

localizes the movement to the spine. Similar starting positions, such as half crook sitting, step standing, or walk forward standing will also eliminate rotation from the pelvis.

FIG. 235.

(2) *Fall hanging; alternate trunk rotation with arm swinging to touch floor* (Fig. 235).—The more usual alternate trunk rotations with arm flinging in such position as prone kneeling, or crosswise sitting, especially stretch front support crosswise sitting in front of the ribstalls, alternate trunk rotation to touch the floor behind with one hand are very useful (see " Back Exercises ").

SIDE FLEXION EXERCISES

(1) *Side falling; holding* (Fig. 236).—May be progressed by raising the top leg and arm to oblique stretch. Also progressed to support side falling on a low boom, or a form.

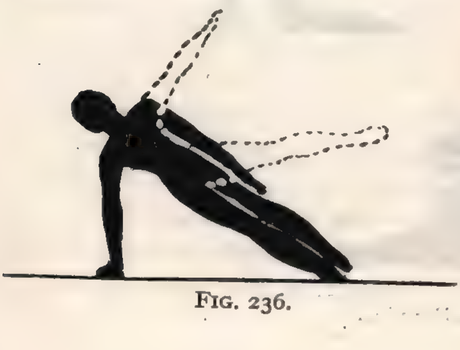


FIG. 236.

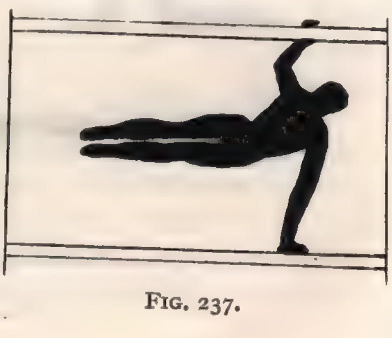


FIG. 237.

(2) *Flank vault to alternate sides* (Fig. 237).
(3) *Reverse hanging; double leg lowering to alternate sides* (Fig. 238).

FIG. 238.

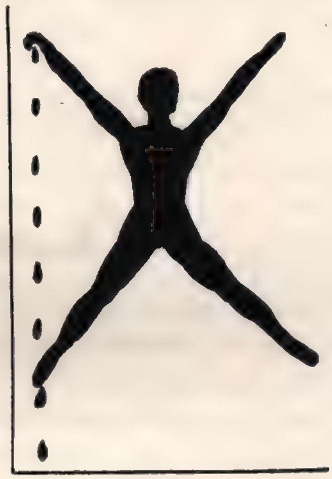


FIG. 239.

(4) *Star hanging; holding* (Fig. 239).

(5) *Heave grasp forward lying; double leg swinging to alternate sides.*—This movement must be localized to the lumbar spine.

EXERCISES TO WORK THE ABDOMINAL MUSCLES

Many exercises described in other groups will be found to contain strong work for the abdominal muscles. To insure these muscles being used and prevent trick movements, the abdominal wall should be slightly retracted before any of these exercises are commenced. Concentric work for these muscles takes place when the ensiform cartilage approximates the symphysis pubis.

(1) *Yard lying, with palms on floor; leg swinging upwards and over head to touch the floor, and slowly lowering.*

(2) *Ring grasp lying; trunk swinging quickly upwards to touch toes, and slowly lowering.*

Static or isometric work is important for the muscles of the

abdominal wall, when the distance between the symphysis pubis and the ensiform cartilage remains constant.

All trunk backward fallings are useful exercises, and can be done in long sitting (Fig. 240), toe support sitting, ride sitting or knee sitting.

FIG. 240.

Simple arm exercises can be done in these fall sitting positions, or simple leg exercises, such as half long half crook fall sitting foot changing quickly, or quick leg abduction and adduction.

CHAPTER XIX

ELECTRO-THERAPEUTIC UNIT: ELECTRICITY IN THE SERVICE OF REHABILITATION

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Introductory.—The following notes represent an attempt to compress into the smallest possible compass consistent with lucidity, the most important features of electrical treatment as applied to the practice of rehabilitation therapy as it is at present understood. Many scientific and skilled exponents of rehabilitation therapy still look upon electrical treatment as a quite unnecessary adjuvant to their work. Some not only consider it redundant but actually harmful to the patient, who is to be restored to normal function by a combined scheme of exercises, occupation and self-help generally. But, capably handled, electricity is an undoubted help in almost any form of rehabilitation work, for it represents a force that enters the body and meets there inherent electrical forces which have weakened or become impaired as a result of injury, or by the gradual degeneration of these forces that inevitably follows old-standing disease, disuse or severe trauma.

Whatever, then, be the original cause of this decay, treatment by electricity does represent a definite force which aids and quickens Nature's great efforts to restore the normal equilibrium of the body's powers. Furthermore, if applied purposefully and with discretion, electricity is a valuable ally to the physiotherapist, for nowadays everyone can think in terms of force or power, and the convalescent, be he airman, sailor, gunner, etc., often knows a great deal about electrotechnics and is encouraged to co-operate intelligently in his own treatment and overcome his own disability. He will do this better than another who is deprived of this knowledge and who merely has the electricity applied passively and mechanically, not realizing the rationale, the aim and the method of his own treatment.

No attempt is made in these notes to enter upon the subject of electrotechnics, nor will the various machines and instruments be even briefly described or commented upon. The readers of this book have all received some training in these subjects and there are excellent text-books which will supply the rest. Here we will rather attempt briefly to consider the effects of such treatment. There is nothing mysterious about the various agents used in medical electricity; these are forces, primarily physical, such as the thermal or chemical effects. These physical effects profoundly affect cellular activity and have a certain secondary or physiological effect, such as an action upon the vaso-motor system or neuro-muscular systems, which can be used either to stimulate depressed power and function or to exert a sedative action on over-excitable tissues. The psychological effect which accompanies most forms of electrical treatment, just as it does in any surgical or medical treatment, is by no means to be despised or neglected, for it can evoke an active and co-operative response which makes for more rapid recuperation.

Heat.—The oldest of therapeutic agents, as old as Hippocrates—represents a reasonable and valuable form of treatment. It gives relief of pain and spasm. It is used with good effect in most sub-acute and chronic forms of inflammation; and is of the greatest value in all rehabilitation work because of its power to soften and loosen contracted and indurated tissues, the result of long immobilization. Heat can be produced either by external sources and brought to the body, or else it is generated inside the body in the deeper tissues. The chief external heat sources are various devices for infra-red or luminous radiations. These heat sources emit radiations, some of which act by warming the surrounding medium; others penetrate farther to the tissues just below the surface, where they are absorbed and transformed into heat energy. Besides the sun, the chief source of infra-red radiation, there are artificial sources; chiefly metal conductors heated by electrical currents and producing luminous and non-luminous radiation. Infra-red or non-luminous radiation is divided into longer and less penetrating, and shorter and more deeply penetrating, rays which penetrate as far as 5 to 10 mm. Infra-red radiation is of importance in rehabilitation work. It produces a profound

dilatation of the capillaries by releasing histamine, a vaso-motor dilating substance, which, when absorbed, results in surface hyperæmia which gradually increases the circulation of the subcutaneous tissues, dilating blood and lymphatic capillaries and acting also on nerve endings in the skin. These radiations can be used for sedative effects or for counter-irritation. They are an indispensable ally in the treatment of innumerable traumatic conditions: spasm, dislocations, fractures, contusion, etc. Also for the relief of pain in many acute conditions: in inflammations of the mucous membrane; in wounds, where their cleansing effect prepares the way for the more stimulating healing action of ultra-violet radiation. In the skin they are useful in the treatment of cellulitis, abscesses, furunculosis, and as a great adjuvant to surgery; also as a preliminary to massage, especially in that dread condition, fibrositis.

Fibrositis is the peculiar and inveterate foe of the Briton, especially of him who has the slightest tendency to, or family history of, rheumatism. It dogs his footsteps in mid and later life, and appears even in the young and healthy, unless it is fought against with vigour. It is apt to form one of the most troublesome sequelæ to war and other injuries. Its treatment comprises four or five principles or headings:

(1) *Heat* (for choice infra-red) applied to the site of injury, which is shown by the formation of tender spots, nodules or hard bands of indurated tissue.

(2) A special form of deep, and not painless *friction* applied to these nodules and bands and always preceded and followed by broad, swifter massage movements directed towards the better emptying of engorged lymphatics of the area. The local injection of an anæsthetic solution into the painful area is of the greatest value here, firstly, for diagnostic purposes, to confirm the exact site of the lesion; secondly, by relieving pain it enables deeper work to be done.

After this rather searching form of friction it is sometimes an advantage to pass a mild galvanic current through the whole painful area. This is not only soothing to pain but definitely helpful in removing toxic products.

(3) Besides all this it is wise to add really skilled *orthopædic manipulations*, not only of the limb in question, but of the whole back, and of the feet, which should never be forgotten.

(4) In all cases a *toxic focus* must be searched for and eliminated. This may be in teeth, throat, nose, gall-bladder, bowel, etc. If it cannot be discovered, colon lavage is always a great aid to fibrositis treatment.

Unless dealt with thoroughly on these lines, biochemical research has distinctly shown that fibrositis, if neglected, leads inevitably to the establishment of a toxic condition that deeply affects liver and pancreas, causing grave metabolic disturbance.

For most of the above-mentioned conditions the more superficially acting forms of heat generated outside the body suffice; but these external sources will never produce a deep hyperæmia which alone can penetrate a joint or reach the internal organs, because the heat-regulating organism of the body immediately dissipates local superficial heat.

Short and ultra-short wave therapy.—To get an even and deep hyperæmia heat must be generated within the tissues by the direct action of electrical energy using high-frequency currents. High-frequency currents of medium frequency, that is to say, diathermy, with its one million oscillations per second and wave lengths of three to six hundred metres, are, however, unable to solve the problem of really deep heating in a complicated organism like the body, consisting as it does of imperfectly connected resistances and capacities, because the diathermy current is limited by tissue resistance and by its predilection for paths of highest conductivity which make it avoid the resistance of bone, fat, capsules, membranes which it cannot penetrate. Only short and ultra-short wave currents with a frequency of 10 to 100 million oscillations per second can do this. In the writer's opinion the manufacture of diathermy machines is now really unnecessary, for their work is far better done, in every department of physiotherapy, by ultra-short wave therapy, which also acts far better than diathermy in the treatment of chronic inflammatory conditions, for under the influence of its deep and homogeneous

hyperæmia hard tissues soften, exudates disappear and cicatricial tissues and adhesions become thinner and more vascular, and its vitalizing effect is soon felt throughout the whole area of pain and disability. Its chief indication is, of course, acute and sub-acute inflammation, where diathermy is contra-indicated. There is a tendency nowadays to minimize the effect of this unique current ; to label it diathermy and calmly to deny to it all effects other than that of heat, regardless of the results shown by many distinguished workers at home and abroad, who claim a specific component besides the thermal factor.

Before rejecting these claims a series of prolonged investigations should be made with standardized apparatus of known intensity and with every refinement of measurement. The final word regarding the full scientific truth of this research has not yet been said. War conditions have stopped a great deal of experimental work, so that until the difficulties of dosage and measurement of energy and exact standardization of experimental conditions are overcome, the problem of specificity must for the present remain unsolved. One thing is certain : if most cases of disability that now fill our rehabilitation centres had been treated in their original acute condition by short-wave therapy there would be far fewer maimed and disabled limbs and less necessity for complicated apparatus with which to treat them. However, so far there are few, if any, short-wave machines in base hospitals, nor are they as yet found in the Libyan Desert. One can only regret profoundly that there are still so many smaller hospitals in this country that failed in the past to provide themselves with adequate short-wave machines, which are now unobtainable.

The galvanic current.—The galvanic or the direct or constant current is the basic and the earliest known form of electrical current flow. It is a unidirectional, uninterrupted flow of electrons. Although its use has been stated to be the most empirical of physical methods and the rationale of its ordered transference of tissue ions to be entirely obscure, there is no doubt that clinically it is beneficial and useful in both its two physical effects, the polar and the inter-polar. The polar effects, with their acid and alkaline reactions, have an extensive electrolytic application in minor surgery. We are more concerned here with its inter-polar effect,

the ordered movement of ions in the tissues and the transport of their water content. *This is true ionization,* that is to say, that the movement of ions which takes place in an electrolyte is the result of the passage of a galvanic current through it. The term ionization is still used loosely and erroneously to describe the introduction into the body tissue of chemical ions for treatment of surface lesions and skin diseases—that is to say, for medical ionization.

More importance was attached formerly to this medical ionization, and the successful results of such treatment were entirely ascribed to the drug, while the factor that really produced the results was the constant current. We know now that medical ionization can only act on the most superficial structures of the body, such as skin and mucous membrane. Medical ionization is so well known to the readers of this book that it is unnecessary to discuss it here, except briefly to mention histamine and mecholyl ionization.

Histamine ionization is extremely useful in treating obstinate patches of fibrositis and rheumatism that have not responded to the usual drugs used in ionic medication. Histamine is a vaso-dilating substance for improving the peripheral circulation, which is easily absorbed if introduced on the positive pole in the form of histamine acid phosphate, or as a histamine ointment rubbed into the skin and covered with a moist pad electrode. It is always followed by a local effect and by some degree of systemic reaction. The initial dose is about a half milliampere per square centimetre of current, which flows for one to two minutes. This is carefully increased at each treatment to three, five or ten minutes at 15–20 milliamperes. After treatment the skin is red and weals appear, which generally recede within an hour. The patient should always be told that a general reaction may take place. This, if too strong, produces headache, tachycardia, faintness. Histamine will relieve pain connected with some tenderness and limitation of movement.

Another vaso-active substance is *cholin,* which stimulates the parasympathetic nerves and thus also dilates the peripheral vessels. Among the various cholin compounds used for ionic medication most work has been done with mecholyl cholin chloride. It is extremely useful in the treatment of peripheral vascular

diseases accompanied by spasm, such as intermittent claudication, which is not uncommonly found in patients of mid-life attending our rehabilitation clinics. It is often the only remedy that affords relief in the agonizing pain suffered by these patients.

Compared to continental workers, English clinicians make but scanty use of the inter-polar effect of true ionization. The late Dr. E. Cumberbatch was one of the few who really appreciated its great benefits. These he summed up in the words: "Vitalizing and refreshing effect of the constant current." He included under this heading its great power to invigorate tissues which had become unable to respond to Nature's efforts to heal. This strengthening effect of the current is a striking phenomenon. It is not really stimulation, for it can be applied to even acutely inflamed nerves; it is the result of the continuous and *unidirectional* movement of ions; this increases the blood supply, thus aiding nutrition and increasing the vitality of the paths traversed by it.

Besides this refreshing effect, the constant current has a sclerolytic action which has been well described by Dr. Dyson, who uses it with great effect in chronic inflammatory conditions to break down the fibrous adhesions of joints and tissues, as in sciatica, lumbago, etc., as well as in the treatment of catarrhal deafness and tinnitus. This sclerolytic action of the constant current is much used in rehabilitation work in the treatment of scars and local inflammatory processes, but the technique is very important: the method used should be galvanic current applied transversely at the site of a nerve or other injury. First short-wave or infra-red therapy should be applied to the same area to ensure vaso-dilatation and assist absorption; cicatricial tissue is then surrounded by a carefully cut-out mask of rubber or other insulating material. Iodine ions are then applied to the injured area on a pad on the cathode in the ordinary way. Fairly strong current is used, and after 10 to 20 minutes of this, induration and contraction will be found much decreased. The treatment can be given every day or on alternate days. If there is swelling due to effusion, iodine by mouth or injection will be found helpful to hasten absorption. All this makes the constant current an invaluable stand-by in rehabilitation centres in the relief of a hundred and one traumatic conditions, as well as neuritis and rheumatism, especially now that

short-wave therapy is so inadequately provided for. The writer often sees the constant current applied inefficiently in these conditions, and this may account for its low standing in the eyes of English physicians. As a rule pads and electrodes are too small and are applied with complete disregard to the lymphatic flow; the time is far too short, and current far too low.

A few years ago the writer had the opportunity of studying the application of the constant current under two of its great and notable exponents—Bergonié, of Lyons, and Kowarschick, of Vienna. At his Lyons clinic, Bergonié treated countless cases of infantile paralysis. For a whole hour, often twice daily, children and adults lay with evident contentment and relief, the whole of the affected limb or limbs enveloped in one large, softly padded electrode, an equally large one over back or chest. Results were all that could be wished for as regards colour, nutrition, rapid improvement of function. Movements, of course, followed, and in the writer's opinion Bergonié's method is superior to bath treatment, which has a grave disadvantage as regards the position of the spine in children. Kowarschick treated with predilection chronic cases of sciatica, which is another of the obstinate and difficult sequelæ in our rehabilitation centres after exposure to sea, wind or damp. He used the constant current only: long electrodes applied back and front to the limb very thickly padded; constant current 70 to 100 milliamperes; time 30 to 60 minutes. Result: excellent.

The writer considers short-wave therapy almost specific for these sciatica cases, but here in England, at present, the apparatus is often insufficient for the number of cases on hand, and Kowarschick's method is a very good substitute. Operators should never forget that these very chronic sciatica cases also need careful graduated treatment by massage for stiffness, with fullest movement, aided by suspension-slings and any device for gradually increasing range and power of movement, and ending with sinusoidal baths to restore lost muscle tone and prepare the patient for walking.

Interrupted currents.—The function of a muscle is movement, and there is no doubt that voluntary exercise of muscles is the ideal form of activity, and that it has the greatest physiological

value; but, as we know too well, electrical stimulation is a vital necessity in our rehabilitation clinics in many cases of weakened and disabled muscles. We use this form of stimulation, firstly, to prevent venous and lymphatic stasis—that is to say, to act as a direct stimulation to the circulation; secondly, to prevent or lessen formations of fibrous matter, and ultimately to break down adhesions, which are the chief cause of disability. Lastly, electrical stimulation is of great importance for its psychological effect; it is a great factor in encouraging voluntary effort on the part of the patient and thus hastening the restoration of normal muscle power.

Low frequency currents are the chief agents for this part of our work. These are currents of low voltage in which the rate of change of flow is below 10,000 per second. This produces a constant change of ionic conduction, and when applied with greater strength leads to stimulation of motor and sensory nerves, resulting in muscular contraction with a good deal of sensory effect. The best known of these are: (1) the interrupted galvanic current; (2) the slow galvanic sinusoidal current; (3) the more rapid forms of surging sinusoidal current; and (4) condenser discharges.

The interrupted galvanic current is used in electrical diagnosis. Although its contractions are not physiological it can also be used in the stimulation of very weak muscles before they begin to respond to a more physiological type of rhythmically interrupted or surging current.

The slow galvanic sinusoidal current is passed through a rhythmic and varying resistance in which the direction of flow is also periodically reversed in its original slow form, with reversals at about 5 to 30 periods per minute. It acts well for stimulation of smooth muscles, and can also be used in the treatment of paralysed muscles without any voluntary power of contraction and in many nerve injuries.

Thus we see that the constant current is at last coming into its own as the outstanding method of choice in artificially induced exercise of denervated muscles. Here, of course, it is the interpolar current interrupted by a metronome. The current is applied longitudinally, with fairly large electrodes to take in as many muscle fibres as possible, and the frequency should be very low to

allow adequate rest between the contractions. There is a very able article on this subject in the May/June number of the *British Physical Journal* by Dr. Philip Bauwens on the treatment of lesions of the peripheral nerves. Like all Dr. Bauwens' work, it is admirable ; scientific, extremely lucid and full of practical hints, and should be carefully studied not only by those who work in rehabilitation centres, but by all who practise electro-therapeutics. Dr. Bauwens lays great stress, as does the writer, on the necessity for warming up the deeper tissues and of accelerating the circulation of limbs before any treatment of nerve injuries by movement, whether active, passive or artificially produced. Here the deep and homogeneous heating produced by short-wave therapy is necessary, infra-red heat being much too superficial. It can be done by the cuff method, or, better still, by using the coil wound round the entire limb.

Surging currents.—For exercise of weak muscles without involvement of the lower motor neuron, surging currents of more rapid frequency, such as the *Leduc current,* with interruptions at the rate of 100 per minute, are recommended. This current produces a definite local anæsthesia and was very successfully used in the last war by Dr. Cumberbatch for the treatment of causalgia, a very common and exceedingly painful affection of the median nerve, of which we had hundreds of cases. Another form of rapidly alternating and modulated current of this sort is the *Morse current,* with 300 alternations per second. This is an agreeable easily modulated and well tolerated mode of treatment. *The Faradic current,* however, is our chief standby for muscle-work. It is used in two forms : In its original form of contraction with marked sensory effect it is used for electrical diagnosis, but the rather brutal tetanising contractions of this current are too painful in its sensory effects to use in the stimulation of muscles and nerves, but by interposing varying resistance in its path it gives us our best known and most valuable form of graduated exercise for weakened but non-paralysed muscles. The Smart-Bristow Coil is perhaps the best known instrument of the Faradic type.

Condenser discharges are chiefly used for exact measurement of current strength in electrical diagnosis. One form of this, the *Lapicque current,* was very successfully used in the last war by

Dr. Turrell. The contractions produced by this are entirely painless, and it has the unique quality of limiting its contractions to the muscle treated, avoiding the troublesome stimulation and antagonistic action of normal muscles in the neighbourhood. All these interrupted currents are so well known that further comment on them is unnecessary, but the writer lays stress on their quality of proving to the most pessimistic patient that the power of contraction is not lost and of stimulating him to voluntary effort, especially if he is allowed to help with the treatment and even apply it himself under supervision. This is a really beneficial measure of self-help.

Light therapy is a great adjuvant to rehabilitation work, and every clinic of this kind should include good equipment for providing local and general irradiation by ultra-violet light.

General irradiation or " sunbaths " should be carried out in a suitably large room with whitewashed walls and floor, in which two or three quartz lamps of the Jesionek type have been installed, together with a good radiant heat lamp suspended above. In this space between the lamps, and at 3 ft. distance, five or six patients can " sun bathe " together two or three times a week with great advantage under skilled supervision and with careful dosage.

In a short time there is a transformation in the appearance of these men, many of whom arrive depressed and debilitated. Besides the pleasant sense of warmth and analgesia of painful areas, there is lessened fatigue and increased cheerfulness. Their skins soon show improvement in colour, tone and an increased resistance to acne and other skin infections, and the dilatation of capillaries induces continuous action on sensory nerve terminals.

The muscles share in the general well-being, becoming firmer and fuller, and the improved general health is accompanied by a definite mental stimulus.

The local use of ultra-violet light is invaluable in the treatment of any accessible septic wound or injury. The sterilizing effect of the shortest, and the healing effect of longer ultra-violet rays is certain and remarkable.

All electrical treatment is, of course, of secondary importance in rehabilitation compared to self-activity, which is the keynote of this helpful book. Over a series of some twelve years the writer

has had ample opportunity of testing the effect of Mrs. Guthrie Smith's wonderful and original work at St. Mary's Hospital, W2, on patients from the electrical and other departments, and she can definitely state that not a patient, surgical or medical, that has been sent by her for suspension exercises, movements in general, and the wonderfully effective massage which is done in that department, has attended there in vain. The improvement which takes place, even in cases that seemed almost hopeless, has in some instances been startling and in all good. What is more, most of the chronic and rather pessimistic cases have returned with a new hopefulness and outlook on life, due not only to the skill and ingenious method in which disabled limbs are handled, but to the spirit of hope, cheerfulness and self-help which characterizes the Exercise Department.

Chapter XX

THE VALUE OF MASSAGE IN CONNEXION WITH SKIN GRAFT AND SIMILAR OPERATIONS

By Sir Harold Gillies, C.B.E., F.R.C.S.
Technical Massage Notes by Miss M. B. Penny, M.C.S.P.

Massage and physical treatment play an important part in the post-operative treatment of patients undergoing plastic or reparative operations. The main types of repair which an operator may be called upon to treat are :

(1) Free grafts of skin ;
(2) Skin flaps.

1. FREE GRAFTS OF SKIN

These grafts are really slices of skin of varying size and varying degrees of thickness. They may be grouped simply as :

(*a*) Thin razor grafts (Thiersch grafts).
(*b*) Thick razor grafts (Split skin grafts).
(*c*) Full thickness grafts (Wolfe grafts).

The grafts, generally taken from the upper arm or thigh, are applied to a granulating surface or a freshly created raw surface. At operation the dressing over the graft is very carefully fixed and a small amount of even pressure may be applied. The whole aim of this procedure is to keep the graft firmly pressed into the recipient area until a " take " has been ensured. The dressing is left undisturbed for a week or ten days, when the graft is examined and re-dressed with a dressing with an oily basis. About two weeks following operation such grafts commence a contractile phase. A graft may become hard, contracted and firmly adherent to its base. It cannot be picked up between finger and thumb as normal skin can. Deep massage with lanoline or olive oil will soften it, and circular kneading movements from the edge to the centre of the graft improve the circulation and help the resolution

of scar tissue. An adherent graft on the dorsum of a burnt hand will become loose and supple after persistent massage (Figs. 241*a*, *b* and *c*).

FIG. 241*a*.—Burnt hands of a sailor.

FIG. 241*b*.—Result of razor graft.

FIG. 241*c*.—Softness and suppleness of the graft the result of massage. Note how the graft is not adherent to the dorsum of hand, and is quite supple although it is shown stretched to the maximum extent.

(Patient operated by Mr. J. B. Cuthbert at E.M.S. Plastic Unit.)

If the surgeon concerned should order massage very soon after the removal of the first dressing care must be taken not to break

the superficial vessels or damage the new epithelial layer. On the other hand it has been found that masseuses are sometimes a little diffident about commencing treatment for such patients. They are afraid of doing harm or that the graft may disintegrate in their hands. They should rest assured that as it is the surgeon who orders the commencement of massage he will know that in his experience the appropriate time has arrived for such treatment (Figs. 243*a* and *b*).

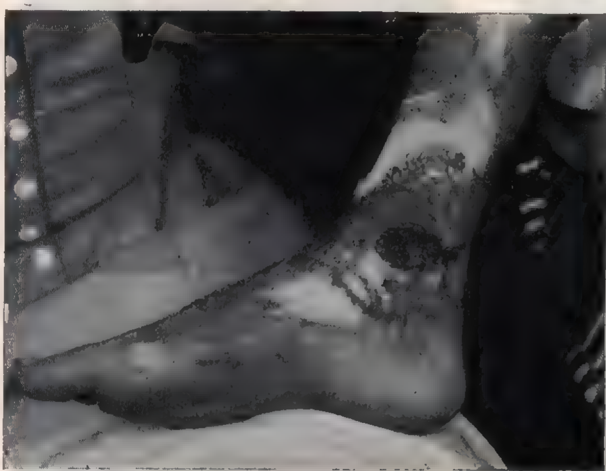


FIG. 242*a*.—Burn over internal malleolus before grafting.

FIG. 242*b*.—After free skin graft was performed local massage to the graft and ankle movements were required.

Manipulation and exercises.—There is a varying opinion as to the value of manipulation of the actual joints in burnt hands and fingers. Some authorities feel that manipulation increases the formation of scar tissue and effusion into the joints. In chosen cases, however, it has been found that treatment definitely improves the mobility of the joints. A factor is presumably the stage of organization of the scar tissue. There is little doubt that in most cases every encouragement should be given to the patient to try to use his hand and fingers. The operator has ample opportunities of studying the mental attitude of the patient whilst carrying out the passive treatment and can then outline exercises

which will hold some particular interest for him. Exercises and movement, the purpose of which are not apparent to the patient are of little value. In this connexion the operator can co-operate with those in charge of rehabilitation facilities for such patients. Similar treatment can be given to children recovering from operations for the repair of syndactyly, but they are generally so

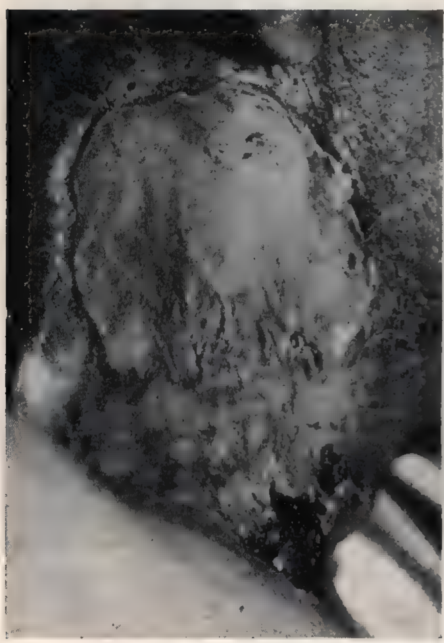


FIG. 243*a*.—Razor graft from lobe of ear to base of neck, as it appeared shortly after first dressing was removed. Rather wrinkled in appearance.

FIG. 243*b*.—Three months later after oil massage.

delighted with their "new" hands that they require but little encouragement to use them.

Forced movements.—The value of such movements has been underrated. In chosen cases definite improvement can be obtained in the joint movement. Although the joint may stiffen up directly after treatment for some weeks, ultimately, after about six to eight weeks, increase of movement is permanent. Any inflammatory signs in the joints or weakness in skin over them contra-indicate such movements.

Splints.—These have been found of value in flexion of the metacarpal phalangeal and inter-phalangeal joints. Splints should be of light material, and the fingers must be free for active movements if elastic traction is provided. As splints invariably impede circulation it is advisable that they should not be worn continuously, but removed, say, at washing and meal times, so that the patient can practise his own active exercises and attempt to use his hands normally.

Wax baths.—These are the best form of heat for skin grafts to hands. The oily substance in the wax lubricates the skin, and by immersion in an arm bath all aspects of the joint are heated simultaneously. This effect is lost unless the wax is heated to 110° F.

Eyelid grafts.—Free skin grafts are often used for the repair of eyelids. Massage in this instance must of necessity be lighter in touch, and sterile paraffin may be preferred as the oily medium.

Fresh air benefits grafts, and, subject to the surgeon's wishes, patients should be encouraged to keep these grafts uncovered. They are not always very willing to co-operate on this point, as they are naturally somewhat sensitive about the wrinkled appearance of the grafts when in the contractile phase. They fail to realize that time and patience are important factors in all plastic repairs. If the period of hospitalization is to be a comparatively short one, such patients can be taught to carry out their own massage at home during the convalescent period.

2. SKIN FLAPS

A flap differs from a graft inasmuch as it is a living, partly attached, piece of skin. During transit and growth into the recipient area it is always attached by one edge or end to some source through which a blood supply can pass to nourish it. For a description of different flaps reference should be made to various books on plastic surgery.

There are three principal ways in which massage can be of great assistance in the after-care of skin flaps:

(1) **Improvement of the blood supply.**—The circulation in the flap itself can be definitely improved. Massage cannot be

FIG. 244*a*.—Burn scarring of soldier's face.

FIG. 244*b*.—Early result of repair.

FIG. 244*c*.—Late result of further plastics and time and massage.

(Patient treated in the first instance at Queen Alexandra Hospital, Milbank, at request of Col. Wallace Benson, R.A.M.C., and then later at an E.M.S. maxillo-facial unit.)

FIG. 245*a*.—Glove avulsion of skin of forearm complicated by a compound fracture of both bones.

FIG. 245*b*.—Showing a direct flap from abdomen reaching from elbow to dorsum of hand.

FIG. 245*c*.—Final result. Massage would be of great value in this case to reduce œdema.

commenced till the stitches have been removed and healing of the suture line is established ; but subsequently an anæmic looking flap becomes quite pink after fifteen minutes kneading between fingers and thumb from the edges to the centre. In each stage of transfer of a tubed pedicle flap it is important to ensure that a good blood supply shall be developed into that end of the flap that has most recently been moved, because this is the end that must provide the blood supply for the next transfer (Fig. 247*a*, *b* and *c*).

(2) **Dispersal of œdema.**—Certain flaps become œdematous possibly because the lymphatic vessels have been divided during

FIG. 246.—Adaptation by the patient to correct position. The shoulder is slightly raised to avoid pull on the flap. Such a patient would require general massage in the neighbourhood to relieve stiffness of the shoulder. On release of the flap he would require encouragement to replace the shoulder into normal position.

the operation. A bulky œdematous flap will not heal rapidly or well. They can be softened with deep kneading movements (Figs. 244, 245). Treatment should be given twice daily, probably for at least a fortnight. Electrical treatments such as anodal galvanism and faradism have been given to the surrounding area, but on the whole deep massage is by far the most effective treatment.

(3) **Fibrosis.**—A hæmatoma may collect in a flap due to small vessels leaking into the slack tissues of the tube. Their presence is

not of necessity very obvious, but manual palpation will discern an abnormality in the texture of the skin. The hæmatoma can be evacuated by the surgeon, but occasionally there is a resultant persistent thickening of the flap. The same type of deep kneading as used for œdematous flaps will help the resolution of this thickening.

(4) **The maintenance of correct fixation and relief of pain in joints.**—In order to keep a tubed pedicle flap in correct position, so that it is neither under tension nor kinked, the carrier limb, such as an arm, may be fixed into a somewhat abnormal

a *b* *c*

FIG. 247, *a*, *b* and *c*.—Demonstrate typical positions.
Reproduced from the *American Journal of Surgery*.

position. The fixation done at the time of operation can in certain patients be relaxed a day or so later and mobility of, say, the limb, shoulder or neck allowed within certain limits. Most patients soon learn the amount of movement they can undertake without dragging on either the stitches or emplacement of the flap and they should be encouraged to move accordingly (Fig. 247). Local heat, preferably infra-red rays, massage and voluntary contractions to the muscles involved help to relieve temporary spasm or pain. An occasion when this may be of utmost value is in the use of tubed pedicle flaps for lower limb defects (Fig. 248).

FIG. 248*a*.—Showing a leg which has suffered considerable loss of tissue.

FIG. 248*b*.—Showing a direct flap from thigh for full thickness loss of the opposite leg. Fixation in plaster causes subsequent stiffness.

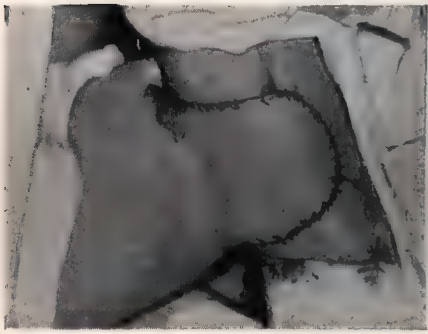


FIG. 248*c*.—An enlargement showing flap attachment.

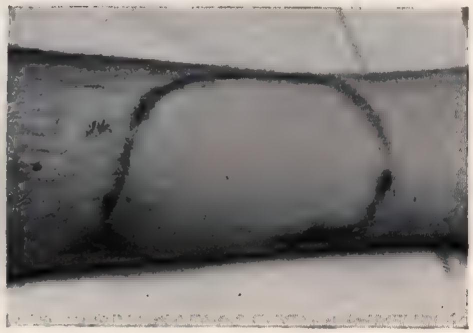


FIG. 248*d*.—Result 3 months after final separation of flap.

THE USE OF ULTRA-VIOLET RAYS

Ultra-violet light has been found useful as a general tonic to the patient and as a means of improving the circulation. Sometimes the healing of flaps and skin grafts is delayed and small areas can be healed by mild local doses of ultra-violet light. The value of light treatment as a routine in the treatment of ulcers is not fully established. Many claims have been made that light or heat in various forms will produce surface sterilization and also promote edge healing. The results, however, are variable and the dosage must be accurately controlled. In plastic surgery this form of

treatment plays a very small part in that the plastic surgeon usually prefers to apply a skin graft to an ulcer either on the granulating surface or after its excision, instead of waiting for the ulcer to heal spontaneously.

NASAL FRACTURES

Following nasal infracture, massage is of help in reducing the persistent swelling which may persist in the upper part of the bridge. Here again patients may be taught to carry out their own treatment. In this connexion it is well to bear in mind that each patient requires individual thought and individual modification of treatment, both as regards strength and quantity of treatment. The guiding rule might well be that what gives the patient comfort must be right. Conversely it is no contra-indication to give the patient discomfort when there is a definite object to be obtained, such as the straightening of a deviated nasal bridge.

The operator can again help not only by skilled local treatment, but by imparting confidence to the patient. Such patients may require daily treatment for about two weeks, but massage should not be persisted in for too long without the express orders of the surgeon concerned.

ASEPTIC PRECAUTIONS

In treating flaps and grafts great care must be taken to prevent cross-infection, particularly in large hospital wards. The operator should scrub up in soap and water before and after treating each patient. Dettol cream should be applied to the finger-tips and nails. The actual massage can be done with soap and water.

When local heat is given to ease positioning it should, if possible, be undertaken without disturbance to the dressing, but if the latter is essential the aid of the nurse should be sought. She may be able to co-operate by arranging the dressing in such a way that it need not be disturbed at each treatment.

PRE-OPERATIVE MASSAGE

Certain scars, particularly those of the "sliced" type, and "U flaps" cause lymphatic obstruction. Much can be done to diminish this and local deep fibrosis by instituting massage for a period of at least three months prior to operation (Fig. 249).

Fig. 249.—Type of "U flap" scarring which can be softened by massage prior to excision.

Chapter XXI

MASSAGE AND REHABILITATION

A reorientation.—In some branches of physiotherapy change and progress have taken place ; but in massage-therapy advance has not kept in step with other methods of treatments. This accounts for a growing tendency to discourage, and even to discard, this most useful and beneficial form of treatment. Any consideration of the physiological effects of massage shows how invaluable it is for restoring nutrition and the circulation of the soft tissues of the body.

Massage has been practised throughout the ages ; it seems to be a natural instinct to apply pressure to a part that has been hurt, or to rub oneself when stiff or cold. It is both an art and a science. The art lies in the fact that there are but a few standard massage movements, but the employment of these movements, either individually or in combination, is capable of infinite variety, whether as regard their shape, form, tempo or rhythm. It is an art that must be acquired by personal instruction ; it cannot be learnt from books or correspondence courses.

That massage is a science is due to its being based on the physiological and anatomical understanding of all the tissues of the body to be manipulated. Physiotherapists must possess a thorough knowledge of the relation of structures with regard to their scope of movement within the covering skin, the exact attachments of joint capsules, pressure-points of nerves and surface anatomy. Since work is carried out for all branches of the medical profession, a fairly comprehensive understanding is necessary of neurological, orthopædic, medical and surgical conditions, in relation to any physical treatments that may be prescribed. Because movement cannot be divided from simple massage the training must include a scientific study of therapeutic movement, or kinesiology.

If this valuable form of therapy is to be preserved, as it should be, and raised to the high level to which it is entitled, then old

ideas must be revised and its technique overhauled ; its application calls for a new orientation.

It is, however, its psychological rather than its physiological effects that have in some quarters brought massage into disfavour. It is objected, for example, that the usual massage seance is too long, the treatments too passive, many of the movements being of a routine nature and superfluous ; that exercises occupy too small a part of the total treatment ; that patients tend to rely for cure entirely on the work done for them.

These, and similar criticisms, are well founded, and it is wise to seek a remedy that conforms with modern views on rehabilitation while at the same time keeping various treatments in their proper perspective. Criticism will be easily answered by a simple, though radical alteration of methods by which the emphasis is laid on the patient's activity rather than on his passivity, and thus the psychological aspect will be completely changed.

Briefly, the needed modifications may be summarized as follows :

(1) Treatments should be shortened, and the massage *interspersed* with exercises. The type of massage employed in a rehabilitation clinic should have restricted, but specific, objectives and be capable of being administered between bouts of exercise. As a result the patient is assured a rest and relaxation period, while the part manipulated benefits by the elimination of fatigue products, and the circulation is refreshed and renewed in preparation for further activity.

(2) Routine and stereotyped massage should be excluded, only the essential manipulations being given. These will vary widely of course, for medical and surgical cases, and according to the diagnosis and conditions the manipulations may vary from a single selected movement to a full general treatment for appropriate cases.

(3) Even ward patients should not lie inactive for a moment longer than is necessary. They must be made to feel that recovery depends largely on their own efforts, however small and ineffective these may seem to be at first. In the

case of this type of patient the treatment will consist of alternations of exercise, assisted if necessary, by massage and relaxation.

Relaxation is as necessary when undertaking a preliminary examination of a patient as it is when preparing for massage. It must precede and follow activity. There is also a degree of relaxation which is available as the result of putting a structure such as muscle or tendon on the stretch. All these simple facts should be made use of to the full in massage-therapy. Moreover, relaxation is required of the operator as well as the patient. Tense hands are uncomfortable ; they also communicate tension to the patient ; a poor starting position is fatal ; both patient and operator should be as comfortable as possible for a successful treatment.

There are so many excellent books on massage already published that go very thoroughly into a description of its technique that in the present chapter only a few selected treatments are dealt with. These treatments may, however, be of interest to the reader, as they have been found helpful in both private and hospital practice.

SOME EFFECTS OF MASSAGE ON THE SKIN

Skin is a highly complex structure, but what we must realize is that it is not only the natural clothing of the body, protecting it against the invasion of bacteria, but a definitely organic structure. It consists of two parts : the derma, or true skin, with its appendages, blood vessels, lymphatics, hair follicles, sweat glands ; and the epidermis, with its four layers, corneal, lucidum, granular and the germinal layer in which important products are developed. Its physiology is, of course, complicated, for it includes important functions : production, respiration, sensation, heat regulation and secretion. It is also an organ of elimination, excreting water, salts and certain waste substances.

Closely covered by a meshwork of sensory nerves, the skin is highly sensitive to even slight irritation, especially when it can act in its natural media, air and light, unhampered by clothing.

As already stated, besides its many functions it produces two vitally important substances which have far-reaching effects. One is melanin, produced in and around the prickle cells of the lower strata. This is its own great protection against excessive exposure to light, whether natural or artificial. The other substance is Vitamin D, produced in the basal layer by the interaction of ultra-violet rays (natural or artificial) on ergosterol, a constituent of cholesterol, and which, though inert in itself, becomes endowed with anti-rachitic power when activated by ultra-violet radiation. These functions and products confirm the view held by most, that the superficial layer of the skin is not only a protective covering but an epidermal organ, and that we can obtain certain definite effects from stimulation or from irritation of this organ. Massage, for instance, has two marked effects : one direct, in that it removes dead layers of skin and increases the circulation ; the other indirect, through the peripheral nerves and skin vessels, and this effect can be used therapeutically, either in a stimulating or soothing sense. For instance :

Indirect effect.—Stroking movements affect the sensory nerve endings in the skin, and, through these, act reflexly on the central nervous system.

General soothing strokings over the spine are used for insomnia treatments, and also for promoting total and local relaxation of muscle.

Effleurage of the limbs over local areas is used to soothe pain and relieve muscle spasm after trauma.

Direct effect.—The sebaceous glands of the skin secrete more sebum and the skin becomes more pliable and softer by the application of friction-like movements. It is for this reason that massage is much used by the plastic surgeon.

Anyone who has seen the end results of plastic surgery combined with skilful gentle massage of the tissues will appreciate the immense value of massage in restoring the circulation and nutrition of the skin.

The gentlest of friction movements should be applied from the periphery towards the edge of the scar or wound. New blood is thus brought to the area, and old congestion, œdema and dead epithelial tissue are removed ; the scar tissue gradually shrinks in

its dimensions and becomes detached from the underlying tissues as described in the chapter by Sir Harold Gillies and Miss Penny.

Skin rolling.—This is a useful movement to loosen tight and unhealthy skin from its underlying structures ; it is most desirable to maintain the elasticity of the skin and to obtain a good, free, loose skin whenever possible. A tight skin binds down and obstructs the superficial circulation.

The manipulation of skin rolling is carried out with loose, light finger movements ; the skin is rolled up against the thumbs by the fingers, and in this way it is liberated as far as possible from the underlying structures. Dry cupping is suggested by Dr. J. B. Mennell, and is a very efficacious treatment. Skin rolling is one of the favourite manipulations to be employed for panniculitis and for superficial obesity treatments.

SUGGESTED TREATMENT OF ŒDEMA (DUE TO TRAUMATISM) : THE VALUE OF EFFLEURAGE

The causes of œdema are so varied and complex that these remarks are confined to such conditions as may seem suitable to the physician for treatment by physiotherapy.

Œdema is an abnormal "collection of clear, watery fluid" within the lymph spaces of the tissues ; tissue tone is lost ; the swelling arises when the natural processes of circulation and elimination become impaired, as by illness, trauma or inaction. Œdematous swelling is common in the limbs of bedridden patients and the physiotherapist is constantly confronted with the problem of treating this condition. For the treatment of such cases one massage movement stands out as of paramount value, and that is effleurage.

Effleurage mechanically assists the venous and lymphatic circulation, as the movement is performed in the direction of the returning blood stream. If the pressure is light the effect will be superficial, but still potent. If deep, more blood vessels and lymphatics will be affected.

Effleurage directly assists the passage of waste material to the glands, removes products of inflammation, prevents and removes

œdema, and assists the reabsorption of serous fluids by its effect upon the lymphatic circulation.

By its effect upon the venous circulation, congestion is relieved and arterial blood is drawn to the capillaries by suction, thus helping the work of the heart. The nutrition of the skin and underlying tissues is greatly improved.

In treatments where the efficient drainage of the limb is the chief consideration it is only logical to elevate the limb. The illustration (Fig. 250) shows the physiotherapist in an unconventional but practical attitude; it is easier to "pull" than to "push" the moulded hands along the surface of a limb. In the position illustrated the limb itself is free from obstructions, and all surfaces can be contacted. The strokes of effleurage will follow the same directions as the lymph stream and end in the glands of the groin.

Effleurage or local stroking to foot and hand.—A good way to relieve swelling or œdema in hand or foot is for the operator to stand facing the patient, so that the hands lie on the dorsum of the foot or hand. The thumbs are placed on the sole of the foot, or on the palm of the hand, in order to make a fixed point from which to work. The hands move from the toes over the dorsum, in quick alternate rhythmic movements, and sweep the swelling away. A deeper effect can be obtained with the same grasp, if the finger-tips are used to seek out each metatarsal or carpal space.

The treatment of œdema should conform to physiological principles, and follow a logical sequence in an attempt to aid both the venous and lymphatic circulations.

Broadly speaking, the circulation can be assisted in two ways:

By negative-pressure.
By positive-pressure.

One of the most valuable means of assisting negative pressure is by controlled respiration: the positive pressure is assisted by appropriate posture in elevation, centripetal massage and active exercises working from the periphery upwards.

The chief factors which maintain *Venous pressure* are:

(1) The pumping action of the heart muscle.
(2) The action of the involuntary muscles of the arterial walls.

(3) The pooling of blood to a head of great pressure, which is due to the peripheral resistance.
(4) The prevention of back-flow by the valves of the veins.
(5) The normal activity of muscles and joints.
(6) The influence of the nerve-centres which control the circulation.

In contrast the *lymphatic circulation* is not affected by all the factors which assist the venous flow, but depends only on :

(1) Negative pressure in the thorax.
(2) The action of the valves in the lymphatic vessels.
(3) The movements of the joints and muscles.
(4) The normal tissue tension which is present in a healthy body.

It is therefore evident that for conditions of lymphatic stasis deep breathing and other methods of mechanical assistance, such as elevation of the limb, manual pressure and joint movements, should prove specially valuable in the effort to restore normal tissue tone.

Alteration of posture : elevation and dependence.—Dr. Buerger introduced some years ago in his treatment of gangrene and vascular diseases of the lower extremities, the idea of placing the leg alternately in elevation and dependence with a rest interval for radiant heat. This reversal of posture has by itself a profound effect upon the circulation. Hutchinson states that, " The action of gravity increases the capillary pressure very markedly ; the pressure in the finger is more than twice as high where the hand is hanging by the side than when it is raised to the level of the top of the head."

Buerger's methods are to treat his patient by laying him flat on the back ; elevating both legs 45 degrees on an inclined plane for two minutes, then changing the posture to sitting, with the feet down for three minutes ; finally laying him flat with a radiant heat lamp or heated blanket over his legs for a period of five minutes. Session ; four to five such cycles, repeated two to four times a day.

ANOTHER TREATMENT SUGGESTED FOR ŒDEMA IN THE LEG

Technique

Elevation.—The leg should be elevated on a sloping plinth so that massage can be applied without hindrance of pillows and bedding, or it may be convenient to suspend the lower limb by the heel at an angle which will obviate knee strain; about 40 to 60 degrees is suitable and gives a good drainage posture (Fig. 250).

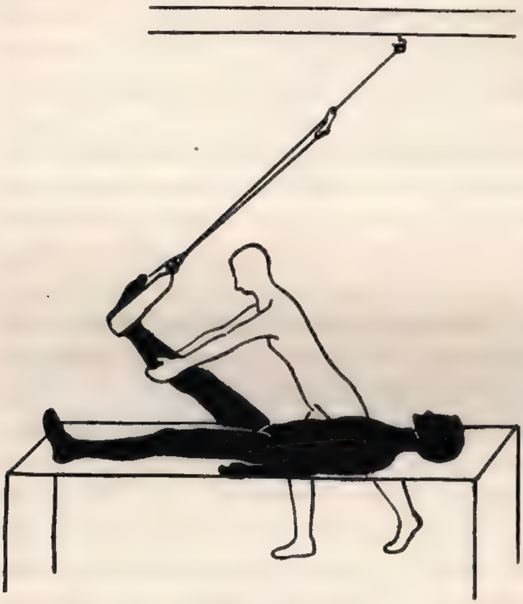


Fig. 250.—Elevation and massage.

Fig. 251.—Dependence

All parts are then free for massage, and at any moment for active exercise. Elevation itself is, of course, a most useful mechanical aid to circulation and drainage. The massage manipulations selected should be those which best assist the circulation; they must be applied to the proximal end of the limb to start with.

(1) Deep and rapid effleurage will aid the flow of blood towards the heart.

(2) Kneading of the pressure-and-relaxation type reaches the lymphatic structures and creates a negative pressure in them.

(3) For very long-standing cases of thick œdema, which is not affected by ordinary effleurage, there is a special movement called the "œdema-crawl." This manipulation is a combination of light superficial kneading and effleurage. It is performed by all the fingers, while the palm of the hand remains in close contact, but at the same time the whole hand must "crawl" up the tissues, pushing the œdema before it to the nearest glands.

Dependence.—The limb is alternately elevated and lowered over the edge of the couch at frequent intervals (say, 2 to 3 minutes) or as suggested by the physician (Fig. 251).

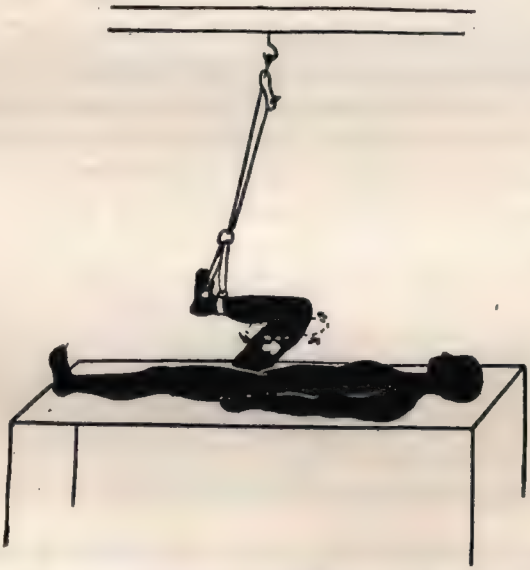


FIG. 252.—Active circumduction of the hip joint.

During the first period of elevation effleurage is given; during the second kneading, and at the third the "œdema crawl."

Active movement (Fig. 252).—On the next elevation the patient should perform active joint-and-muscle movements, starting at the periphery, and working towards the centre in the following manner: The toes are bent and stretched three times, and then held in flexion; the ankle is then dorsi-flexed and held; the toes remain in flexion, the knee joint is then bent and stretched and then held in flexion; finally the hip joint is circumducted

three times while all the other joints are held as tightly as possible in the position indicated ; then *the whole limb is relaxed.*

These active movements help to pump the blood and lymph from the periphery upwards.

The same movements can, of course, be carried out for the arm and will be found of great benefit when treating œdematous conditions of this area. I am indebted to Dr. Justina Wilson for teaching me these exercises, which were used at the Heart Hospital in London.

Finally, lying on the back with the leg suspended in elevation ; joint exercises such as active hip rolling follow. Such movements should be performed with vigour.

Deep breathing can be carried out, particularly during the periods when the limb is in elevation. If this is done great aid to the circulation is possible, owing to the increase in the negative pressure which is set up in the chest by deep respiration.

To sum up.—The circulation is assisted by :

(1) Variation of posture.
(2) Centripetal massage ; effleurage ; kneading ; œdema crawl.
(3) Passive and active movements of joint and muscle.
(4) Deep breathing.

ADDITIONAL PHYSIOTHERAPEUTIC MEASURES

Other physical methods are useful adjuvants to this technique.

Radiant heat soothes the nerve-endings and has a beneficial effect upon the superficial lymphatics and vascular constituents of the skin.

Rubber bandages.—Bandaging the leg from below upwards with broad rubber bandages has often been suggested by Dr. J. B. Mennell, who finds it a valuable means of restoring lost tone to the subcutaneous tissues. Exercises are performed under the bandages, the resistance of which adds to their toning properties.

Faradic current is also useful ; the electrodes are strapped over the motor points of muscles before the rubber bandages are applied. Graduated faradic contractions against the resistance of

the bandages are of great service in exercising the muscles before their tone has sufficiently improved to allow the patient to do strong active movements.

"**Contrast baths**" of alternate hot and cold water produce good vaso dilatation and so are useful for œdema; they will also soften swollen structures after the removal of plaster.

ATONIC MUSCLE: MUSCLE-KNEADING AND "CO-OPERATIVE PRESSURES"

Muscle-kneading (*pétrissage*) of the limb is performed by both hands working in alternate rhythms from above downwards; the muscles are rolled against the bone, squeezed and picked up in elliptical movements, the emphasis being on the up-stroke, and relaxation on the down-stroke of the ellipse. Soothing or stimulating effects depend on the tempo of the movement: a slow rhythmic movement is soothing, whereas a quick movement is stimulating. The depth of the pressure will depend on the condition for which massage is ordered.

Each fusiform type of muscle is picked up individually when possible from its origin to its insertion; the flat and bulky muscles are pressed against the underlying bone so that the whole area is gradually covered. The alternate pressures set up in the muscle substance by massage influence the fluid contents both venous and lymphatic.

As the venous circulation is hastened more arterial blood will be drawn to the part by suction, and the nutrition of the muscle will be improved. It is a matter of common experience that the products of fatigue in muscle are liberated by kneading; indeed, far more quickly than in any other way, except by the injection of certain drugs.

Recent research in America on the effects of massage have disclosed that massage does not affect the muscle chemically; "there is neither production nor loss of lactic acid; but the blood supply is improved, and this factor will tend to remove any excess lactic acid." * This accounts for the refreshing feeling experienced by

* *Physical Medicine.* Krusen.

persons who have been given massage when suffering from muscle-strain or stiffness.

Pétrissage.—Pétrissage should be of special value in rehabilitation where one of the major aims of physical treatment is to restore the soft tissues to good condition. Pétrissage interspersed between bouts of active exercise will have a refreshing effect and create a useful rest period for the patient.

It is well understood that massage by itself does not produce tone ; active movement is required for this purpose.

A new method of muscle treatment is therefore advocated by means of which active movement and massage can be carried out at one and the same time. The therapeutic effects will then be not merely refreshing but tonic ; the name given to this treatment is " Co-operative Pressures."

Massage has often been looked upon as a luxury treatment in which the patient did nothing at all, except enjoy or dislike the performance, according to the nature of the treatment. Sometimes most valuable rest and relaxation was obtained in this way, but more often it was looked upon as a treatment with unlimited opportunity for talk on ailments and other equally fascinating subjects. By the employment of this new technique it is suggested that the patient will take a share in his own treatment.

Massage with co-operative pressures.—By " co-operative " pressure is meant a united effort on the part of both patient and operator to obtain a maximum tonic and circulatory effect on small localized areas of muscle tissue ; these pressures can be given to *any* muscle. As an example, let us assume the gluteus maximus to be the muscle selected (Fig. 253).

Technique.—After a good but limited preliminary kneading and friction, the physiotherapist asks the patient to contract the muscle, while she applies her loosely closed hand with the flat proximal-phalangial area over that part of the muscle where the greatest contraction is felt (Fig. 253). A definite degree of pressure is then applied, so that the next contraction made by the patient will be *against* resistance (Fig. 254). This process is repeated three or four times and constantly interspersed throughout the massage treatment. These active movements metabolize waste products, new blood is brought to the part, a flushing action is

obtained and the muscle will gain nutrition and tone. This treatment requires concentration on the part of both patient and operator, the patient's attention should be directed to his share of the treatment.

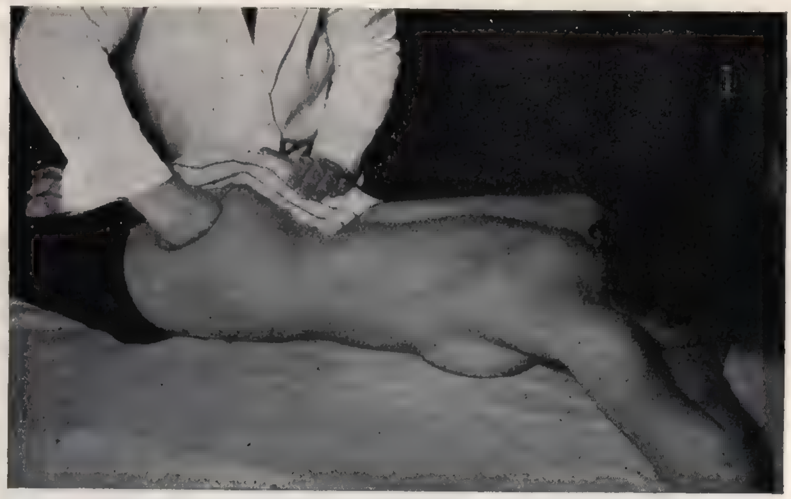


FIG. 253.—Co-operative pressures—(*a*) in-pressing and pressure.

FIG. 254.—Co-operative pressures—(*b*) patient contracting.

Massage itself will not produce tone, but any active movement, however small, is of value.

The alternate work and rest period lessens the fatigue for the operator, and as the good results are doubled by the combined effort, the method would appear to be well worth adopting, because by *superimposing* active movement on to a passive manipulation a shorter, more concentrated, and efficient treatment is obtained. The physiological effects of two otherwise separate treatments will reinforce each other, circulatory, thermal and tonic properties being combined.

This treatment has proved very beneficial for the long-standing rheumatic cases, for back treatment and all types of atonic muscular

FIG. 255.—Co-operative pressures.

Areas to apply pressure for the better toning up of trapezius, latissimus dorsi and the gluteus maximus are indicated by the dark circles.

conditions. It is satisfactory often to find a definite increase in tone within a few days of starting these co-operative methods. " Difficult " patients who will not help in their own case and those who dislike doing exercises and think it a waste of time, will still carry out co-operative pressures, as they do not realize it is a form of exercise, and it is not necessary to enlighten them! (Fig. 254.)

Massage of erector spinæ.—A special friction manipulation is indicated for this muscle in order to secure good results. The muscle should be transversely palpated from its origin to its insertion. It will be felt lying in the groove formed by the spinous

and transverse processes of the vertebræ, lying as far out, but no farther, than the angles of the ribs. In most healthy people the muscle is well defined, except in the upper back. In order to carry out this movement the physiotherapist stands at right angles to the patient's side (Fig. 256), and the movement is performed with the eight finger-tips; the muscle is palpated and rolled transversely between the transverse and spinous processes of the vertebræ up and down its entire length with a frictional movement. It is well to follow the transverse friction by co-operative pressures. Both hands are then applied to either side of the spinal column, and three

FIG. 256.—Transverse frictions to erector spinæ.

deep pressures are made with the thumbs over an area of the muscle. This is followed by three *active contractions* made by the patient against the pressure of the operator. These movements are carried down the whole length of the spinal column, and will produce more tone in the erector spinæ. Longitudinal hacking and deep thumb effleurage to the supra-clavicular glands make a good conclusion to the treatment.

The effects of frictions are mechanical; as in kneading, they have the object of removing the products of inflammation and exudation by the alternate pressure and relaxation set up by the manipulation.

After some experience of the manipulation, it is interesting to

observe the facility with which fibrous nodules can be detected and transversely manipulated.

Pressure and relaxation (Figs. 257, 258).—This is another

FIG 257.—Pressure.

FIG. 258.—Relaxation

manipulation of great value, chiefly used for massage of the neck and back. The technique is as follows: The thumbs are pressed deeply into the muscles where they overlie bone, and then relaxed

with a give-and-take elasticity. This movement is designed to act as a suction pump to the lymphatics in particular. The lymphatics of the back and neck lie deeply buried under masses of muscle ; by removing congestion in these tissues relief from pain and pressure will be felt. The effects are deeper than the standard massage manipulations ; the pressures are given from the top of the neck to the base of the spine. The patient must co-operate by fully relaxing the body.

For the limbs.—Pressure and relaxation can also be applied to the limbs. The hands press the tissues against the bone ; then after deep pressure they are relaxed. The treatment starts at the proximal end of a limb.

FIG. 259.—Pressure and relaxation, using a sloping board.

For the joints.—The author is indebted to Dr. Higgins, of Cambridge, for showing his pressure and relaxation technique, which he based on anatomical work on the lymphatic system, and to the late G. Pratt, C.S.M.M.G., for many excellent demonstrations of the method. Dr. Higgins stated that very light but definite pressure and relaxation with the thumbs round the edges of a joint capsule has a satisfactory effect in liberating the circulation of the joint. This manipulation, if carefully applied, will cause a suction in the lymphatics, and may relieve that tight feeling sometimes felt round a joint. This tight feeling is often due to constriction of the edge of the capsule, and the circulation

in the distal parts is hampered by this factor. It is thought that wasting of the muscles of the hand in rheumatoid arthritis may partly be due to this cause.

A practical massage bench can be constructed out of a 12-in. wide wooden plank. It can be padded and fitted with hooks for tilting to any angle to suit the operator. A narrow bench is so much more convenient for back massage, as a good vertical pressure can be given. It also has the added advantage of being quickly dismantled and stands flat when a clear floor space is required. This is an important point in a busy department. (Fig. 259.)

FLACCID MUSCLE

Massage undoubtedly assists the circulation of paralysed muscles, but the ideal massage manipulation must never bruise the delicate tissues nor stretch the weakened muscles. Therefore it is suggested that a vibratory form of massage is especially useful in early cases of paresis. Yet it must be powerful enough to set up deep influences *in* the tissue cells, to hasten the internal respiration, and to bring blood to the part. It is best performed in the following way : The muscle should be grasped gently between the first finger and thumb of the right hand, gently and slowly shaken from side to side, then faster and faster, till in a few moments the whole muscle is shaking and vibrating largely by its own momentum. Paralysed muscles tend to hang limply between their origins and insertions, and they are easier to manipulate than muscles with normal tone. Biceps, triceps and the calf muscles are the easiest to vibrate in this manner. Patients appreciate and commend this particular manipulation. It is safe, never bruises, yet is deeply penetrating. It is advised that this manipulation should be given between exercises—as it is so refreshing in its effects.

Manual vibrations are applied both vertically and transversely, and are performed by very fine flexion and extension movements of the muscles controlling the wrist. The arm should be relaxed, and the fine vibrations are carried through the finger-tip or hand itself. Vertical vibrations are applied to organs, muscles or nerves.

Transverse vibrations are obtained by very fine abduction and adduction of the wrist muscles and carried through to fingers or hand. This type of vibration is applied to tissues which run in a longitudinal direction, either nerves or muscles. The effect on muscle is to cause stimulation without nerve impulse. It is a most refreshing manipulation. The tissue tensions are altered and a mechanical effect is obtained which probably accelerates the interchange of gases in the tissues.

ABDOMINAL STASIS

Generally speaking, abdominal massage has both a reflex and a mechanical effect upon the organs. The pressure is never so heavy as to be uncomfortable, and should not be applied in too vertical a direction, but rather transversely, as in this direction the organs move freely from side to side.

Physiotherapists must investigate all areas before starting massage, and should be seated on the right side of the patient to palpate, and to become familiar with the condition and tone of the abdominal wall; and also to ascertain the tension (fluid or gaseous) of the tissues.

The best time of the day for abdominal massage is said to be the early morning, when the stomach is empty, except for a cup of hot tea. The fluid starts off the reflexes favourable to peristalsis; massage will reinforce this action and so aid nature.

Peristalsis consists of two phases, contraction and relaxation; this wave travels down the bowel and sweeps the intestinal contents before it. The bolus is said to be propelled along at "an average rate of 9 cm. in 8 minutes." The normal stimulation to peristalsis is distension of the intestinal wall by the food masses within it, but it is well known that the involuntary muscles are also influenced by "associated movement" which is set up between them and the external abdominal wall. It is in this way that massage assists peristalsis.

The stomach.—The lowest point of the greater curvature may reach to the level of the umbilicus while the fundus is in contact with the diaphragm. The stomach is, therefore, J-shaped and will vary in size and position according to its contents. It is emptied

by muscular contraction of a peristaltic nature which starts about the middle of the body of the stomach and sweeps downward and towards the pylorus. The wave of movement is faster over the greater curvature than it is over the lesser. These movements have been called the "gastric cycle," and are said to occupy about 20 seconds for each cycle of contraction and relaxation. It takes about 3 to $4\frac{1}{2}$ hours for the stomach to empty itself; water passes through at once, semi-fluid meals pass far more quickly than solid meals. Evacuation is more rapid if the subject lies on the right side than it will be if lying recumbent on the left side, in standing or sitting. This should be remembered when giving massage for certain conditions, such as gastric distension and atony. The intra-gastric pressure is influenced by, and varies with, intra-abdominal pressure and movements of the respiratory organs, so that breathing exercises reinforced by trunk movements will definitely be indicated for toning-up purposes of this organ. All movements must be carried out with rhythm and precision. The "Supported Trunk Exercises" described in the chapter on ward cases will be found very suitable for gastric treatments. (Fig. 167.)

For an atonic stomach much can be done. The chief manipulations are stroking, kneading and a coarse, slow vibration. All these movements pass from the left hypochondriac region along the line of the left under rib region as low as the umbilicus, and end at the pylorus (Fig. 260, A). These movements relieve discomfort and a sense of fullness, and have a reflex and a partially mechanical effect.

This treatment is contra-indicated in diseases of the heart, as it causes the distended stomach to be pressed upward; this is felt by the patient as a disagreeable sensation. Acute dilatation of the stomach is sometimes a dangerous result following on abdominal operation, and is due to sudden loss of abdominal tone.

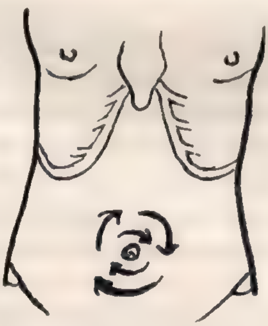
When flatulence and severe dyspepsia are present only very light vibrations and strokings can be given. These are kept up from 10 to 15 minutes. They soothe the patient, dispel the gases and produce an almost analgesic effect on the area. This type of treatment may be suitable for heart cases which are associated with gastric disturbance.

The liver.—The liver lies well protected under the lower six

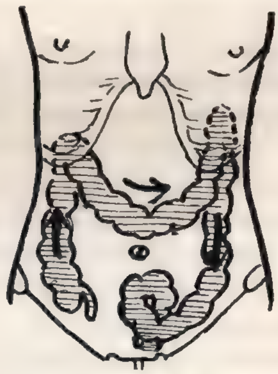
ribs, but it can be influenced reflexly, and through the ribs mechanically. The movements most used are percussions and deep squeezing pressures applied over the lower six ribs on the right side while the patient lies on the left side. A torpid liver can thus be stimulated by percussions applied over the right lower ribs, but,

A. Stomach stroking

B. "To-and-fro" kneading to the small intestine.



C. A soothing movement for spasm of the intestines.



D. Manipulation for the colon.

FIG. 260, A to D.—Diagrams represent the direction of massage manipulations.

above all, by exercises which incorporate side bendings and flexion movements.

Gall bladder.—The gall bladder can be vibrated by inserting three fingers under the right costal margin, at the level of the ninth costal cartilage, just at the point where this muscle is

intersected by the semi-lunar edge of the rectus abdominis muscle. By raising the patient's head this point can easily be palpated. The vibrations are said to reflexly stimulate the flow of bile.

The spleen.—One of the chief functions of the spleen is to act as a blood reservoir. The stimulus which liberates this extra supply of blood occurs when the CO^2 content of the blood is raised, as it is by exercise. At this time the splenic contractions increase, and extra blood is automatically delivered into the circulation. Apart from periods of exercise, the splenic circulation is slow, even sluggish, but in time all the blood passes through the organ for sorting out of the old dead red corpuscles. The spleen alters in size after a meal, and there is an increase of leucocytosis. Another of its important functions is the formation of anti-bodies.

Massage indirectly influences the spleen, and *deep* abdominal massage must affect it by the alternate pressure and relaxation which is set up. This point was once investigated at St. Mary's Hospital, W.2, when it was found that the blood count was increased after such massage. The spleen can be *gently* vibrated through the ribs with benefit. The manipulation is carried out along the oblique line of the 9th, 10th, 11th ribs from the spine to the mid-axillary line.

The small intestine (Fig. 260, B).—This gut moves freely in a pendular movement as it hangs in its mesenteric attachment. This " to-and-fro " movement can be imitated by massage, a pressing away of the abdominal wall and underlying structures with the heel of the hand, and drawing them back again with the finger-tips. This movement, followed by vibration, is said directly to stimulate the functions of digestion, absorption and peristalsis in the area.

Diuresis.—One interesting effect of abdominal massage has often been noted, and that is there is a definite increase in the flow of urine.

The colon.—For constipation, the chief areas of congestion are the rectal, splenic and hepatic flexures. There are various types of constipation, atonic, spastic and rectal.

(*a*) *Atonic constipation* may be due to lack of vitamin B. This type of constipation is said by McCarrison to be very prevalent in arthritic people. He investigated many such persons and found

65 per cent. of them had constipation, and the remainder had persistent and prominent dilatation of the colon. All these persons improved with a diet of less carbohydrate, and the addition of yeast to the food. Dr. Justina Wilson has always advocated abdominal massage for the rheumatic out-patients, and there is no doubt that they react well to this treatment, especially when it is followed by generalized class exercises.

(*b*) *Spastic constipation.*—A spastic colon leads to spastic constipation. This tiresome complaint causes contraction of the transverse and descending colon. The gut feels like a hard cord on palpation, but the spasm may be confined to the transverse colon only, when a definite ridge can be palpated. This contraction does little or nothing to help on the food substances. Spastic conditions are very commonly found in people suffering from mental or business worries, and in those who indulge in irregular and hasty meals. These patients must relax in mind and body and put their treatment and its cure before their business.

A good manipulation for spastic-colonic condition is a small continuous circular movement round the region of the umbilicus (Fig. 260, C). If this is kept up while the patient relaxes and breathes deeply, the spasm in the colon will be relieved; the cord-like tension can be felt to give way. After a time more generalized vibratory movements may be given, but the relaxation of the spasm is the chief object of treatment.

(*c*) *For rectal constipation.*—The rectal area should be first emptied by an enema (olive oil or paraffin enemas are best for chronic constipation). Massage treatment, starting on the descending colon from the splenic flexure to the pelvic colon, will then be of benefit (Fig. 260, D). The chief massage movements for this area are stroking, kneading, finger-tip kneading and circular frictions; all the pressure will be given from above downward on the descending colon. The effect of this pressure will have some mechanical advantage, as this gut is more fixed than other parts of the alimentary canal; it can often be palpated in the left iliac fossa. "Sacral beating" is indicated for its stimulating and reflex effects upon the rectum; lumbar kneading, with the patient in prone lying, will be helpful; this should be followed by deep pressure and relaxation manipulations applied close to the spine.

The cæcum can be moved and a suction effect achieved by placing the closed proximal metacarpal area of the right hand over it, pressing in during a deep breath, then releasing the pressure. The ascending colon is treated with the same manipulations as those for the descending colon, but the pressure is upwards.

The flexures are hidden under the ribs, but some appreciable effect can be obtained by strong stroking and alternate shaking, or vibrations applied over the lower ribs so as to squeeze the sides of the body together. This movement gives comfort and relief to stout people with a distended colon, and stimulates the colon in these parts.

" Mass " peristalsis occurs in the colon at intervals, three or four times in twenty-four hours. The reflex which stimulates this movement is the gastro-colic reflex, *i.e.* immediately after the entry of food to the stomach. The movement is said to start at the hepatic flexure ; the wave carries all before it through the transverse and descending colons.

The abdominal wall.—Abdominal massage has a direct effect on the circulation and nutrition of the abdominal muscles. Tapotement is often advocated, as it tones up muscle by striking the fibres in a transverse direction and so causes a contraction. This movement on the abdomen is, however, most disagreeable to many patients, and in some subjects it sets up an *antagonistic reflex* ; therefore it should not be given unless well tolerated.

Lack of abdominal tone leads to dilatation of blood vessels in the digestive organs, and favours the formation of fat.

If the abdominal muscles are weak, and the general tone of the patient below par, then the blood tends to subside into the great abdominal veins and capillaries ; thus the heart and brain will get a lessened share, because there is a definite reciprocal action between the splanchnic system and the peripheral parts of the circulation. The liver, spleen and lungs act as reservoirs of the blood to the circulation. If the abdominal muscular tone is poor blood will sag down under the action of gravity. Long confinement to bed impairs this normal compensating process. Massage will not produce tone, but all active movements, however small, are of great value and must be gradually up-graded till tone is restored.

CHRONIC RHEUMATIC CONDITIONS

This group of diseases forms by far too great a proportion of the out-patients in the department, and its treatment by physiotherapy is often dull and slow in results. Many factors play their part in the ætiology of the different forms of rheumatic disease confronting us in the wards and out-patients' departments; but putting aside all ætiological considerations, we may roughly divide chronic rheumatic diseases, referred to physiotherapeutic treatments, into three groups:

(1) Non-articular rheumatism (fibrositis).
(2) Osteo-arthritis.
(3) Rheumatoid or multiple arthritis.

NON-ARTICULAR RHEUMATISM (FIBROSITIS): "STRETCHING-TRACTION" AND MASSAGE

Chronic fibrositis.—Chronic fibrositis is a sub-acute inflammation of the fibrous supporting tissues of the body. It is often associated with obesity and trauma. Septic foci are usually the underlying cause.

The condition gives rise to masses of inflammatory matter which appear to form and are arrested between the fascial layers of muscles in the subcutaneous tissues, deep in the capsules of joints, the tendons of muscle and the nerve sheaths. These masses can be palpated and felt as indefinite rope-like substances resembling seaweed; sometimes they are more definite and localized in shape, such as a pea, seed or watery nodule.

Pain is at first increased by massage, as the congested areas have to be pressed upon deeply by very localized to-and-fro pressures until the object felt is disturbed and if possible wrested away from its adjacent structures. If this can be done the lymphatic circulation will get a chance to intervene and by its unrivalled drainage system carry away all inflammatory deposits. After a period of massage the pain lessens and the patient appreciates the relief, even though feeling somewhat bruised.

Pain arises from congestion which is set up in limited spaces. The areas most affected are those where the circulation is not

vigorous, such as in the aponeurotic attachment of muscle to bone, or where tendons are inserted near joints.

As fibrositis is due to an inflammation of the connective tissues we shall expect to find this condition in those parts where this type of structure is most prevalent in the body. The lumbar region is very heavily braced with connective tissue, the intercostal muscles are very tendinous structures, and the muscles at the nape of the neck and back of the head have abundant connective tissue. It is in these areas the complaint is chiefly found.

Fibrositis can be classified into various types :

(1) Panniculitis.
(2) Teno-synovitis.
(3) Intra-muscular fibrositis. (*a*) Lumbago, (*b*) stiff neck, (*c*) pleuradynia, (*d*) peri-neural fibrositis, (*e*) peri-articular fibrositis.

(1) **Panniculitis.**—In panniculitis the subcutaneous areas become infiltrated and an inflammation of the superficial structures appears to take place. This condition is very much the fate of the middle-aged and stoutly built individual, and is prevalent in those living in damp districts.

The usual treatment prescribed for chronic cases is infra-red therapy, followed by vigorous skin rolling manipulations. By these means the skin is loosened and the circulation increased. The treatment is painful and should be gradually progressed in strength, to end with a course of active exercises and joint stretchings.

The results of treatment are often very encouraging, but unless the underlying causes are eradicated, the condition may recur.

(2) **Teno-synovitis.**—The fibrositis will now be more localized, and confined to the areas where the tendon of a muscle enters into its insertion. Vigorous local massage-frictions applied transversely across the tendinous structure in the way advocated by Dr. James Cyriax will generally relieve the condition. If the limb can also be put on stretch—gently and progressively—by an outside force, and the muscles relaxed, massage will penetrate more deeply and effectively.

Static traction, with the use of apparatus, is usefully applied to the region of the shoulder joint in particular. Traction will

assist the operator to give better manipulations to the tendinous structures, which are inserted into the upper end of the humerus, and the position will put the joint capsule itself on the stretch (Fig. 266).

(3) **Fascial and intra-muscular fibrositis** is one of the commonest forms of fibrositis, giving us the too familiar pictures of (*a*) *lumbago ;* (*b*) *stiff neck ;* (*c*) *inter-costal neuralgia* or *pleuradynia ;* (*d*) *peri-neural ;* (*e*) *peri-articular.*

(*a*) **Lumbago**.—Attacks of lumbago can be so very acute that rest and fomentations or infra-red rays and only the gentlest massage can be tolerated. When the very acute stage is passed faradism can be given, and the following technique is useful to know. The faradic current should be applied through two large pads placed over the lower back so that an effect is produced over large areas ; if the current is then gently surged, small waves of contractions can be produced in the muscles ; this will cause metabolic changes to occur. These changes will liberate toxic substances, and at the same time lift the tissues away and free them from one another. Faradism is followed by effleurage, which will assist the lymphatic circulation, the movements being all definitely directed towards the glands of the groin. As soon as further treatment can be tolerated deeper kneading is given over the lumbar area. Dr. Justina Wilson describes this kneading as follows : " A circular movement with very gradual penetration is applied ; later a deeper movement follows which will penetrate below the subcutaneous fat into the depths of the muscles which must be completely relaxed."

This technique enables the remaining deep nodules to be more easily palpated ; then the technique is changed and movements are altered to maintain purposeful frictions until the nodules are broken up. Dr. Justina Wilson advocates that exercises should follow her prescription, especially " those movements which cause the body to be stretched," for she says : " the patients suffering from this complaint display the energy of a snail and loathe and bitterly resent any self-effort. Very few patients suffering from fibrositis fully extend their arms above their heads and rarely hyper-extend and thoroughly stretch the muscles of their neck and back during the course of the day." How true

these remarks are all physiotherapists working in an out-patients' department know only too well.

(*b*) **Stiff neck.**—*Head and neck treatments.*—In practice it is very helpful to apply the Swedish head-suspension apparatus to patients suffering from fibrositis of the neck. Head traction gives something which is missing in all other forms of neck treatment; and it is regrettable that it is not more generally applied. Patients who have had this form of head traction—combined with electricity, heat and massage—have found their muscles freed for further active work, in a way that is not easily gained by other means. If this Swedish head-suspension apparatus is too drastic or not available, an alternative method of traction can be given. The patient lies with the head comfortably supported in a spring-suspension apparatus, such as illustrated in "Regional Exercises" (Fig. 83). The physiotherapist will now give manual traction, and all passive movements can be carried out under such traction; finger-tip massage can be neatly applied to the regions of the sub-occipital triangle, where the nodules and thickenings of fibrositis are usually felt. It is at this point below the occiput that the tension caused by fibrositis sets up pressure on the occipital nerves. This causes pain to be referred to all branches of the nerves, so that the head aches, the scalp is tender to touch, and pain is communicated sometimes as far as the branches of the fifth nerve; even the region of the front of the scalp becomes painful. If this thickening can be attacked at its origin, the nodules will be dispersed and much relief from such symptoms will be felt.

(*c*) **Inter-costal neuralgia: pleuradynia** is a form of fibrositis which may be due to a combination of circumstances, such as a primary septic focus (pyorrhœa), fatigue, possibly a muscle rupture, or onset of a bad chill. The condition may become so acute as to give rise to agonizing pain, especially in the inter-costal region. In the case of torn muscle no treatment can be tolerated except rest, strapping of the muscle, and drugs. Gentle vibration can be applied manually over the strapping and will help to remove stasis. Infra-red rays will be found to be most soothing, and can be applied as soon as the strapping is removed. Once the pain has subsided more vigorous massage can be given with detailed work to the whole thoracic cage, and to the lumbar muscles as far

as the crest of the ileum; but it is very important to stretch all the muscles attached to the ribs, so that no lurking adhesions remain in the tissues.

Trunk flexion, rotation and side-flexion exercises of various sort can be given with good effect. Those illustrated give a good type of self-activated movement which will take the patient safely to the limit of pain, and make sure of complete freedom from adhesions, the range of movement being very extensive if this simple apparatus is used. (Fig. 261.)

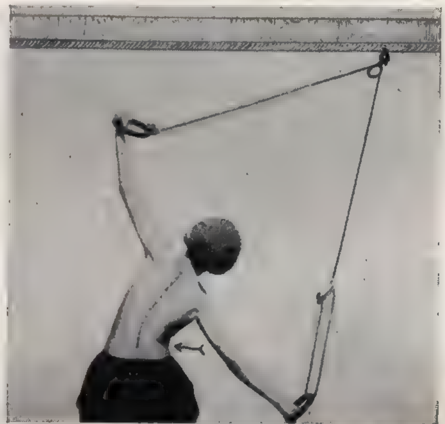


FIG. 261.—Yard stride standing, side flexion, to stretch thoracic structures on the left side.

(*d*) **Peri-neural fibrositis.**—A case of anterior-crural neuritis of fibrotic origin was treated at the Swedish Institute Clinic and may be of interest, as the onset was typical of an acute attack.

The cause was a combination of toxæmia and fatigue of muscles. The toxæmia was directly attributable to a row of septic gumboils which had been scraped and the pus swallowed, but the teeth not extracted. The fatigue was due to a great deal of walking which had to be undertaken at that period. The patient described the onset as follows:

The leg went heavy quite suddenly. A rest and hot bath did not cure the fatigue. The next day the patient was quite unable to move or to get out of bed. A doctor was sent for, drugs were given and antiphlogistin applied. The muscles of the upper thigh felt

tender and painful and "*raw.*" After a time these got better but a red-hot pain began to run down the thigh, even when lying still; this, however, was not constant. Whenever the hip joint was moved or the position changed the pain was much increased and became stabbing in character. The pain extended till it gradually reached as far as the great toe, exactly following the course of the anterior crural and long saphenous nerves.

After 5 to 6 days the condition was eased. As soon as the patient could be moved the teeth were extracted and colonic lavage given, but after 10 days the thigh had already lost $1\frac{1}{2}$ in. girth and it took nearly three months before normal measurements were restored.

Physiotherapy was given in the form of infra-red rays, then very gentle massage, as massage could not be tolerated at first. When the acute condition had passed the whole of the muscles and ligaments and the joint structures were gently stretched till full joint range was achieved. To the thigh vigorous muscle massage was applied; to the anterior crural region chiefly frictions were given as many sharp granules were palpable.

In these cases of fibrositis, once the inflammation has subsided in the inflamed structures, the patient appears to welcome the feeling of the part being stretched. When a full stretching technique has been instituted it will be found that adhesions are prevented from forming and the circulation of the joint is then quickly restored. Graduated faradic contractions and muscle toning exercises against resistance completed the recovery in this case.

In nearly all the above-named fibrotic conditions there is a tendency for the connective tissues to contract. This has been so frequently pointed out by Dr. Justina Wilson in her writings that the author has thought it as well to think out ways of procuring a stretching technique which can be applied with heat, massage or electro-therapy.

The following illustrations show how traction can be given in two chief directions; vertical: along the long axis of the body or limb; horizontal: so that the muscles and fascia can receive a lateral and progressive stretching. This technique will also satisfy Dr. J. B. Mennell's contention, that "It is important to be able to stretch intermuscular connective tissue. This tissue contracts

from various pathological reasons and greatly disturbs function. Massage and slow stretching combined together will be far more effective in overcoming this condition than will massage alone."

(*e*) **Peri-articular fibrositis.**—The fibrositis has now penetrated into the deeper structures, and the inflammation may attack a deep tendon which has an essential duty in stabilizing a joint. A short stabbing pain may then be felt, which if it is in the leg will cause the subject to go dead lame for a moment, or a period of time. In

FIG. 262.—Horizontal traction—heat and massage.

Stretching-traction to the limit of joint movement. Note the position of the operator and the ease of control which is available if the limb is first suspended.

these cases palpation will often reveal little hard, grain-like substances along the course of the tendons. The breaking down of these is certainly painful, but the patients welcome the treatment and ask for more, as they realize that the sharp pricking sensations they feel are the cause of the pain.

The writer's experience of this condition is that some form of heat, preferably damp heat, is necessary, even if it is only a succession of fomentations and hot-water bottles. Localized

massage is essential, and is applied at the same time as a careful stretching of the joint. For example, if the hip joint is under treatment it should be stretched in its fullest range of flexion and extension, the patient being in side-lying, then supine with *full* abduction to the absolute limit of joint-movement. The process goes on slowly but surely, and is accompanied by full or limited passive stretching and massage; this is followed by swinging movements under the patient's volition. Daily, free swinging

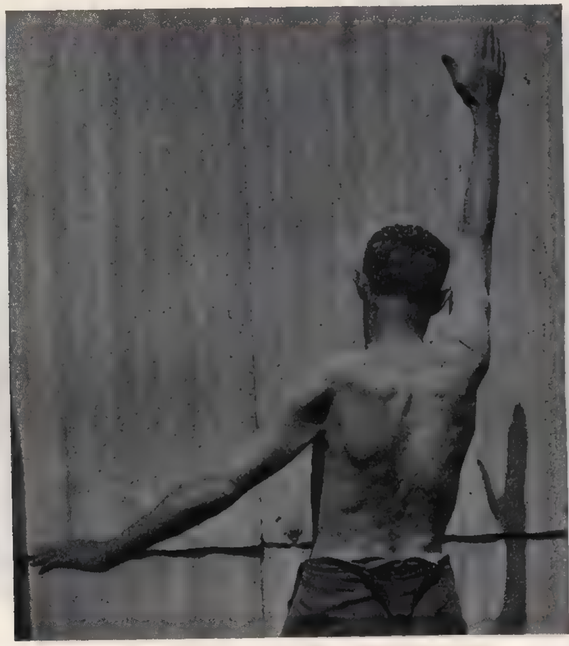


FIG. 263.—The same patient as in Fig. 264, showing extent of voluntary movement.

movements should be continued till the full range of movement is acquired with the relaxation and support available with suspension apparatus. As soon as possible the patient should be asked to co-operate by making small active movements of the muscles antagonist to those that are being stretched (in this case the abductors must work a little) so as to obtain the fullest effect of the relaxed stretching (Fig. 262).

Vertical traction.—The application of vertical traction by the use of sling suspension will be found useful in overcoming

many difficulties when treating joints. The peri-articular structures can be progressively stretched, and all parts of the joint made accessible for treatment by massage, electricity and heat ; as a preliminary to self-activated movement. This method may

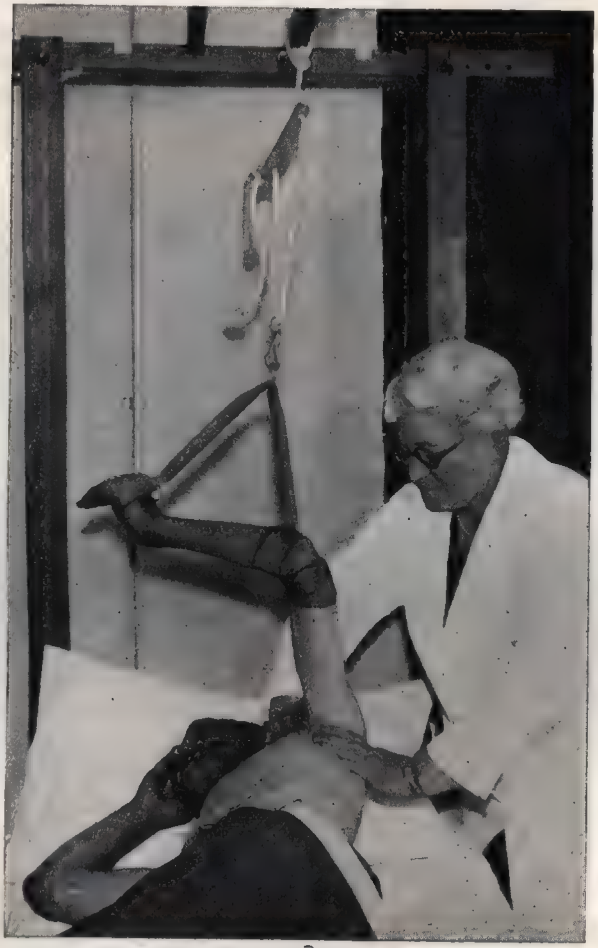


FIG. 264.—Shows method of vertical traction and how abduction and relaxation are obtained for the treatments shown in the four following illustrations.

be of value in selected cases, when the tissues have suffered contraction.

The shoulder joint and adjacent structures (Fig. 264).—The patient lies on his side, the arm is gradually raised from semi to full

abduction, the forearm is placed at right angles to the arm, both arm and forearm are supported by means of a rope-and-sling device, dependent from an overhead bar. The rope exerts an upward tensile force which can be graduated by the adjustment on the rope, according to the condition of the joint. The patient should try to relax, and then by himself exert a downward traction

FIG. 265.—Kneading of shoulder joint capsule under traction. All parts of the joint, even the axilla, are free for manipulation.

FIG. 266.—Friction under traction.

from the sling support. In this way traction is divided, the patient doing 50 per cent. of the work, while the tension of the rope does the remainder. From time to time the tension should be completely relaxed so as to prevent any interference with the circulation.

Massage under traction.—Figs. 264, 265 and 266 all show the arm most favourably placed for massage, the whole region of the joint being exposed for treatment. The capsule on all aspects can be

manipulated with double-handed kneading, and friction can be applied to the extremities of the tendons which form the anterior and posterior folds of the axilla—the favourite spot for fibrotic nodules—which will be easily found. If the patient is properly relaxed in this position, the massage penetrates deeply into all the relaxed but fibrosed structures, which are thus automatically stretched and sorted out. Massage by deep friction will of itself accelerate the stretching process, this is followed by manipulation of the scapula.

Fig. 267.

Fig. 268.

Scapula movements. The weight of the arm is carried by the overhead traction, so the operator is assisted and only supplies extra traction if it is required during the passive movements which are being given to the scapula.

Passive movement under traction.—Figs. 267 and 268 show how, with the rope somewhat slackened, the scapula can be grasped and manipulated against the chest wall in a rotary manner ; in this way thickenings and adhesions can be broken which tend to adhere the scapula to the ribs. Rotation in and out of the humero-scapula joint can be tried out, and the range of passive and active movement gauged under traction.

TRUE ARTHRITIS: SOME SUGGESTIONS FOR TREATMENT

Although rheumatoid or multiple arthritis does not respect age, sex, or type of person, our chronic rheumatoid patients as a rule are the younger and rather delicate women under 40, whereas the osteo-arthritic cases are more often of a stouter build and frequently of a more active and energetic disposition.

From the physiotherapist's point of view it is important from the outset to gain patients' confidence and to enlist their full co-operation, for only then can a complete scheme of treatment be worked out, which even in severe forms of chronic rheumatic disease will make their future lives more tolerable, and useful.

The first stage of treatment in all the rheumatic groups enumerated is entirely medical: to establish the diagnosis; to discover and set on foot means whereby foci of infection can ultimately be arrested or eradicated; to secure *rest*, mental and physical; to relieve pain; and to institute suitable diet. All this will contribute to raise the general resistance. At this stage the physiotherapist may be required to give a short series of ultra-violet baths, which act as a mental tonic and a physical stimulus. The principal work, however, at this stage, is to establish contact with patients, instructing them in relaxation and breathing exercises.

OSTEO ARTHRITIS

For the typical knee joint of the osteo-arthritic patient a new massage manipulation is suggested because it is particularly suitable for this type of patient and is much appreciated by them.

Kneading of the capsule of the knee joint.—A manipulation specially designed to reach the capsule is carried out as follows: With the patient's leg in extension, the capsule will be at its slackest tension, and its folds (which are stretched in flexion) will lie above the femur. Therefore the knee must be fully extended and the muscles relaxed.

The capsular structure should be carefully located (even surface-marked as a preliminary), so that the hands may be placed at the exact edges of the capsule. The two hands work the tissues towards each other in a lifting movement in such a way that the

skin, fascia and capsule are all pressed towards the centre of the joint. The soft, loose membrane can then be moved beneath the fingers ; this double membrane, with its rich lymphatic supply, will greatly benefit from this localized massage. It is an ideal manipulation for osteo-arthritis when the joint lacks fluid, and the synovial membrane is stiff and avascular, but it is absolutely contra-indicated for the puffy joints of rheumatoid-arthritis or synovitis. In these cases disposal of fluid is needed, vibrations or œdema manipulations being required.

FIG. 268A.—Kneading of the capsule of the knee joint.

There is a large plexus of sensory nerves associated with the knee joint and its reflexes. Gentle stroking will directly influence these nerves, and thus act reflexly on the central nervous system. One good movement is carried out with the thumbs placed just above the patella. They seek out the edge of the bone, travelling outwards and downwards, then crossing below the patella, travelling upwards and outwards. The effect of the movement is soothing and pleasant, and is useful in the treatment of painful conditions such as for arthritis and injured knees.

Movement.—For regaining movement in the stiff joints of the osteo-arthritic type the reader is referred to the " Oscillatory Exercises," which are described in various parts of the book. These new exercises have been successfully used at some of the Ministry of Health and London County Council hospitals where the opportunity has arisen of increasing the scope of the suspension

exercises. The system has been developed to include spring-therapy, so that patients can now obtain exercise with small oscillatory movements controlled entirely by themselves. Very rigid joints are thus brought under a treatment which is assisted by apparatus only in so far as the initial starting position of the joint is automatically maintained, the active work being entirely voluntary, though minimal in quality and quantity. Thus joint mobility and muscle tone are developed together. This type of treatment is eminently suited to selected cases of the osteo-arthritic type and are described in the chapter on " Rehabilitation of the Warded Patient."

RHEUMATOID OR MULTIPLE ARTHRITIS

Patients suffering from rheumatoid arthritis find it very difficult to relax, so every effort should be made to make their position comfortable ; they must rest and conserve their strength. The body should be stretched out as much as possible, and if they can roll over into a prone position even once daily it will do much to preserve the correct position and alignment of the body. Deep breathing should be a routine treatment. These breathing exercises create confidence and promote relaxation and so make a useful early contact between the operator and patient. Also at a later stage, breathing given with each movement of a painful joint is very helpful in obtaining the co-operation of the patient and aids us by distracting the patient's attention from the painful part.

The remainder of the treatment can be divided largely into two parts : *local* to the painful areas and *general* to those parts of the body which are either not affected or which have passed the acute stage.

Local treatment.—Massage and heat in some form having been prescribed for the patient, it is as well to have a scheme ready which is safe and gentle, and which will not aggravate the painful condition or stir up further trouble. To this end the massage is confined chiefly to the atonic muscles. Some effleurage is given to the whole limb, the joints themselves being included in the effleurage but *not* in the kneading. The chief aim of treatment is to help the muscles, so that they do not atrophy ; to accelerate the circulation so that the tissues receive better nutrition. Tensing

of muscle is usually indicated as the safest exercise at this stage of treatment.

(1) *Massage.*—Kneading and effleurage to all the soft tissues, which should be of a gentle, rhythmic nature, will prevent too much disuse-atrophy of muscle. The area of the joints should be avoided.

(2) *Movements* * should be strictly limited to one single movement in each direction and controlled as follows: *One joint is moved once only in each direction,* but this may be carried out in several small stages. The operator supports the part under treatment between the two hands in such a way that no weight is felt by the patient. The patient is asked to breathe in and move the joint under treatment, say, in flexion, a little way at a time against slight resistance (or no resistance).

The movement is continued inch by inch until the joint works in the innermost range of its movement. When the limit of voluntary movement is reached the patient should relax the limb while it is still being held in full flexion by the operator; another deep breath is then taken, accompanied by a further attempt to flex the joint. It is best not to force these movements, but to rely on the encouragement of voluntary effort. For extension all the movements are carried out in a similar way, little by little, until the limit of voluntary effort is reached; but expiration and extension go better together. These simple movements should be purposeful, quiet, and free from jerks; muscle tone will then be increased, while the joint surfaces will not be unduly irritated by these single movements in each direction.

On no account should to-and-fro movements such as arm bending and stretching spring or pulley exercises be permitted while any acute joint condition is present, as this tends to irritate the inflamed joint surfaces and may cause the disease to spread to other areas.

General treatment to the non-painful non-acute areas.—It is often found that the patient has one or more acutely painful joints which may still be in plaster, but that other joints have passed this stage and can be safely treated by physiotherapy. The aim of treatment is now to encourage self-activity, so that the muscle and joint strength will develop together. Massage can be more vigorous, perhaps faradic stimulation introduced, but above all, easy,

* Local movements after Hesta Angove, M.C.S.P.

rhythmic movements should be started. Tensing exercise should be taught, so that every muscle that can be used in contraction has a chance of being kept in as good tone as possible.

Limb exercises.—One method of carrying out this type of slow rhythmic work is by weightless exercise in suspension. The limb is comfortably supported in wide slings, gravitational forces being removed, all that is necessary is for the patient to relax and to get used to the slung position before starting minimal exercise of muscle and joint. Bilateral suspension is advocated.

General activity for bedridden patients.—Suspension apparatus gives to bedridden cases an aid to *self activity* and exercise which cannot be given in any other way. This will be found of value in restoring or improving their morale, which is so essential in the long-drawn-out convalescent period, and for obtaining their intelligent co-operation when it comes to further remedial measures, which may, alas, be of a somewhat painful nature.

Cases of multiple arthritis always have some parts of the body which are less affected than others, and it is to these better areas that the general treatment should be directed, as it will not cause fear nor give pain but will rather create confidence. The treatment should not be unduly hurried : loss of confidence is fatal. Bedridden patients can take advantage of the pendulum rhythm as the movements are smooth, without jerk. A greater range of movement will result as strength returns.

Precautions.—The reaction to the first few treatments must be carefully noted : there may be an increase or decrease of temperature, sweating or excitement, cheerfulness or tears may result. At first the suspension exercises should be given for only a few moments and with great caution, but if all goes well the whole body, except the joints in plaster casts, can be gradually exercised. Any increase of swelling or pain on the following day will be an indication that too much has been attempted, and a couple of days of complete rest will be a wise proceeding.

Quite a number of such multiple arthritic patients have been given this local and general treatment at St. Mary's Hospital, W.2, chiefly in the Inoculation ward under the late Sir William Wilcox and Dr. Porteous. Dr. Porteous was one of the first medical officers to order a special suspension apparatus for his own wards,

as he was anxious to obtain some interest and exercise of a general nature for his bedridden cases.*

Chapter XXII

OCCUPATIONAL THERAPY AND REHABILITATION

By Nellie I. Lanckenau, M.D.

Modern rehabilitation methods, especially in hospital, are not complete without some form of occupational therapy.

All the usual forms of physiotherapy, such as radiant heat, massage, exercises, ultra-violet light, and electrical treatments, physical training and games, have a definite place in rehabilitation, but there are gaps in the course of days and weeks in which the patient without occupational therapy is more or less left idle and just waiting for the healing of the affected tissues.

It is these gaps in the daily life of the sick or injured patient which may hamper and delay recovery. The patient either becomes introspective and worries about the future or develops an attitude of mind which becomes less and less inclined to exertion, the repair of the tissues is delayed, as without volitional movement the circulation is sluggish.

Rehabilitation of the sick or injured, whether in hospital or in private practice, must start at the earliest possible moment, *i.e.* while the patient is still recumbent in bed and as soon as the general condition of the patient permits.

In the Physiotherapy and Occupational Therapy Department under my supervision in Sector 6, Emergency Medical Services, the patients' day is planned so as to include physiotherapy, occupational therapy, games and recreational therapy, and the patients progress through graduated stages to full activity.

There are three stages of progression :

1. PHYSIOTHERAPY AND DIVERSIONAL OCCUPATIONAL THERAPY

In the first stage physiotherapy and diversional occupational

* For the inoculation wards the standard suspension unit was built and designed so that it could be wheeled in and out of a line of beds. In this way many patients could be dealt with, and no permanent fixture over the beds was necessary. When work was finished the apparatus was placed in the centre of the ward.

therapy take precedence. The physiotherapy part of the programme takes a major share of the day and prepares the way for occupational therapy. Radiant heat, massage and suspension exercises relieve pain and so aid muscle relaxation. Then, by definite resistance exercises in sling suspension, with pulleys and weights, the weak muscles are stimulated and strengthened, poor posture is corrected, and muscle co-ordination effected.

General ultra-violet light baths have a stimulating effect on the skin, and there is improvement in the general health when these light baths are available, especially in winter weather.

It is during this first stage that the patient is glad to have some occupational therapy of a diversional type, *i.e.* something to do, which can be taken up at odd moments and laid down again, but something which holds the interest of the patient and encourages the idea of activity.

2. PHYSIOTHERAPY, DIVERSIONAL AND REMEDIAL OCCUPATIONAL THERAPY

In the second stage, physiotherapy and occupational therapy are planned so as to occupy more or less an equal time in the rehabilitation programme and definite remedial or specific occupational therapy is introduced.

3. SPECIFIC OCCUPATIONAL THERAPY

In the third stage occupational therapy becomes a whole-time job, mainly of the specific remedial type, interspersed with recreation and walking exercise, until the patient is discharged either back to duty or to a definite revocational training centre under the Ministry of Labour.

Classification of Occupational Therapy

Occupational therapy is of necessity largely diversional in character in most hospitals, but in some of the larger E.M.S. Hospitals, where a special department is set apart and staffed with a trained occupational therapist and auxiliary workers, occupational therapy can be conducted and classified into three main groups :

(*a*) Diversional;
(*b*) Orthopædic or specifically remedial;
(*c*) Revocational.

(*a*) **Diversional occupational therapy** can be carried out in any hospital or adopted in private practice by an operator; indeed, this work can be done by any intelligent sympathetic friend or visitor or voluntary worker in a hospital.

A knowledge of arts and crafts, of needlework and hobbies is a great aid in this work, but common sense and a sympathetic insight of the patient's requirements will help enormously. I know of a small hospital where the operator realizing the need for diversional occupational therapy introduced it with success to her patients: she had common sense and a real understanding of the psychological needs of her patients. By the purchase of instruction books on hobbies and crafts and by making known the need for material and tools she interested voluntary workers in the scheme, and was soon able to relieve the tedium of life in recumbency by some interesting activity. It is amazing how much hidden and latent talent will come to the surface amongst patients in a ward, and the benefit derived from mutual help and encouragement is considerable. As soon as one patient sets to work on making something, the other patients get caught up in enthusiasm to create some piece of work, and there is a wholesome sense of rivalry developed.

(*b*) **Orthopædic or specifically remedial occupational therapy** is best achieved in a special department or workshop. This group have a larger selection of work to choose from, but if necessary this form of occupational therapy can be taken to the wards, provided the co-operation and goodwill of the sister-in-charge is enlisted.

In this category the patient can select leather work, joinery, rug-making, toy-making, basketwork, weaving, painting, printing, plastics, shoe repairing, tailoring, bookbinding, etc.

(*c*) **Revocational occupational therapy** is essential for those patients who are unable to resume their former employment; it enables the patient to train in some other work or craft, and so eventually become a wage-earner again. In such cases the

occupational therapist should discover the patient's proclivities and educate him from the first in the preliminary stages of his chosen career, so that he may emerge from hospital ready to work in the vocational centres of the Ministry of Labour.

Let us suppose, for instance, an electrician has lost the use of his hand. An early investigation of his aptitude for some craft or trade will stimulate his interest and give him an urge to overcome his disability. By means of an artificial limb or modified apparatus he can become an adept at the loom, using his feet for the major part of the work.

The occupational therapist in this group can do so much to help patients over that difficult time when realization of their disability may be so overwhelming that the future appears hopeless.

The occupational therapist who is fully trained for this work requires an active brain and agile body as well as a sympathetic insight into the psychological needs of her patients, and the whole work must be done in a happy atmosphere of mutual co-operation.

Psychological approach.—The importance of this psychological approach to the patient cannot be stressed too strongly. It is worth while to spend a little time on finding out the subject which interests the patient ; just being occupied with some work which bores the patient will do him more harm than good. The patient is first bored, then irritated, and even angry at having to do something he dislikes, whereas, after a talk or two, he would have given a clue to where his interests should be directed. The whole secret of success is the ability to comply with the voluntary requests or suggestions from the patient.

The so-called diversional occupational therapy is psychologically remedial in character, the patient is interested, mentally alert, and has something to look forward to each day, and while he is working there is increased hyperæmia of the brain and limbs, pain is forgotten in the absorption of the work.

Illustrations of Remedial Occupational Therapy

Case 1.—A gunner who sustained a gunshot wound in the left shoulder, 4.5.42. After treatment of the wound, stiffness of fingers developed. The patient was sent for physiotherapy on

29.9.42, and the main disability then was stiffness and limitation of extension of fingers of the left hand. On 5.10.42 he was sent for special remedial occupational therapy, and was set to work for a definite time daily at fretsaw work, making jigsaw puzzles.

The enthusiasm for work and the concentration in holding down the material with both hands, guiding with the right unaffected hand and pressing down with the left, enabled him to pass the time pleasurably, and he was conscious of the fact that the limitation of extension was gradually diminishing.

In the Physiotherapy Department he had special finger exercises on a hand minature suspension frame with weights and springs for mobility of the fingers.

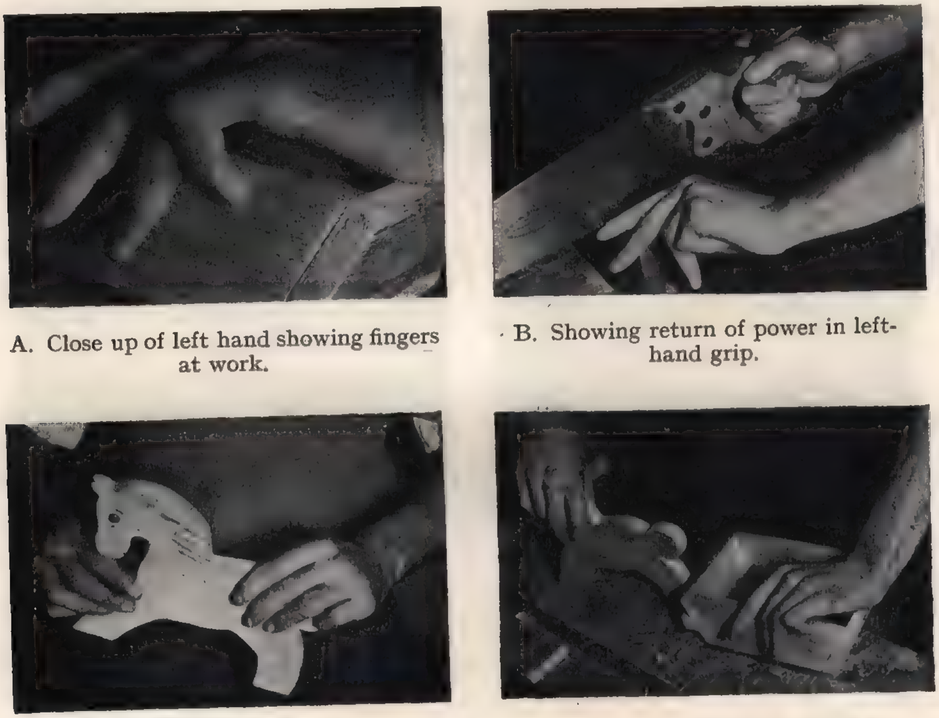
A. Position at fretsaw work. B. Close up of fingers.

FIG. 269.—Case 1.

Case 2.—A lorry-driver a year previously had a septic blister develop in the cleft between the third and fourth fingers of the left hand; this was incised and the wound healed. The two fingers, however, became gradually flexed, so that the terminal segments of the fingers pressed firmly into the palm of the hand seven days after operation; the index and middle fingers were unaffected. On 28.10.42 he was sent for specific remedial occupational therapy and the photograph was taken on 4.12.42. The patient was encouraged to use both hands, and as he was keen on joinery he was set to work in the carpenter's shop. Once there, he forgot his disability, and, as the photograph shows, the third finger is almost straight and the little finger is being used during work.

This patient has made some remarkably good wooden toys and is seen making a toy horse and cart.

Case 3.—Admitted on 18.2.42 for fracture of the lower third of the right humerus on 15.2.42. He was sent for special remedial occupational therapy on 4.11.42 because of weakness of right arm and hand. The photograph was taken on 4.12.42, and he is seen



A. Close up of left hand showing fingers at work.

B. Showing return of power in left-hand grip.

C. Close up of work showing extension of third finger.

D. Horse and cart toy made by patient.

FIG. 270.—Case 2.

working at a lathe, using a chisel with good effect. This patient also made wooden toys and other articles ; his pain and weakness were forgotten in the pleasure of active work.

Case 4.—A naval man who had weakness of hips and back was sent to our department for general strengthening treatment. He liked joinery, so he spent the greater part of each day in the carpenter's shop, making full use of his time and enjoying his

treatment. The photograph shows him at the lathe on 4.12.42, and he was ready for discharge back to duty.

A. At work on lathe during general strengthening muscle-work treatment.

B. Injured right arm at work on lathe with chisel.

FIG. 271.—Case 3.

Illustrating use of affected hand on fret-saw.

FIG. 272.—Case 4.

Case 5.—A median nerve injury of left hand, this patient, a soldier, selected weaving. He made an excellent length of cloth of his own design. The photograph was taken on 4.12.42, two

days before returning to his unit. Photographs show the patient working at a loom, and to vary the programme he worked also on jigsaw puzzles, using a fretsaw.

The modern method of rehabilitation suspension exercise is of great value in conjunction with this specific remedial occupational therapy. Weak muscles can be exercised daily for definite periods and a record chart kept to show the increase of power and movement. Then the patient spends another period of the day using

A. Working at the loom using left hand to exercise muscles supplied by median nerve.

B. At work on fretsaw using left hand to hold work.

FIG. 273.—Case 5.

these same muscles in some creative work, with less and less fatigue, and by combining the training of muscles for special work by selected suspension exercises, the possibility and danger of trick movements at work can be eliminated and the value of occupational therapy enhanced.

The judicious application of treatment by physiotherapy, physical training classes, games and occupational therapy is essential, and for this there must be close co-operation between physicians and surgeons and staff of the respective departments.

Appendix I

NEW SUSPENSION APPARATUS

(a) THE "BED GYM"

The "Bed Gym" portable model is designed to be of use to the Physiotherapist who wishes to carry out exercises in the patient's home. It must be understood that a *single* point of fixation can never be as useful or as accurate as a full suspension frame, but owing to its portability, it should be of great use to the skilled operator for the treatment of convalescent patients, where the patients need some help and support during exercise or for eutonic exercises.

Description of the Apparatus

The Bed Gym is made of three parts—a base and two upright poles.

(1) *The Base* is adjustable in width. It is placed under the legs of the bedstead and is thus held in position by the weight of the bed, and also by a counter-lever action of the cup-shaped fittings.

(2) *The lower telescopic pole* is screwed into a fitting in the base. It is held in position by a movable padded clamp, which is adjustable, and fixed to the bedstead rail.

(3) *The upper pole* is slipped into the aforesaid telescopic pole, and screwed in position. This part is fitted with hooks to carry both sling gear and the springs.

The apparatus when erected is about 6 ft. 6 in. high and stands rigid at either the top or the foot of the bedstead, as required.

When folded up for carrying, the three metal parts are housed in a canvas roll and carried by straps; the whole measures less than 4 ft. in length and weighs a few pounds, so that it is easily carried and will fit into a small car. The rope and sling gear is carried in a box, which is also designed as a "foot rest" for the patient. The apparatus can be set up and attached to a bedstead in a few moments; with it a number of supported or resisted exercises can be carried out for both trunk and limbs.

The rest of the gear is made up as follows:

A body belt with shoulder straps, fitted with D-rings—Fig. 166, D.
A strong (100 lb.) spring—Fig. 166, E.
A swivelling pulley—Fig. 166.

[*Nursing Times*]

FIG. 274.—The Bed Gym.

Showing the apparatus set up on foot of bedstead. The legs are supported and the patient carries out cycling movements, or hip rolling, or leg out-thrusting.

A rope, 4 ft. long with adjusters and spring clips.
Two canvas belts to support the limb action.
Two rehabilitation springs (35 lb.)
Eutonic Units, Fig. 8, E, F, D.
Two 3-ring belts for the feet—Fig. 7, B, B^1, B^2.
The foot rest is used as a receptacle to house this loose gear.

(a) (b)

FIG. 275.—The Bed Gym.

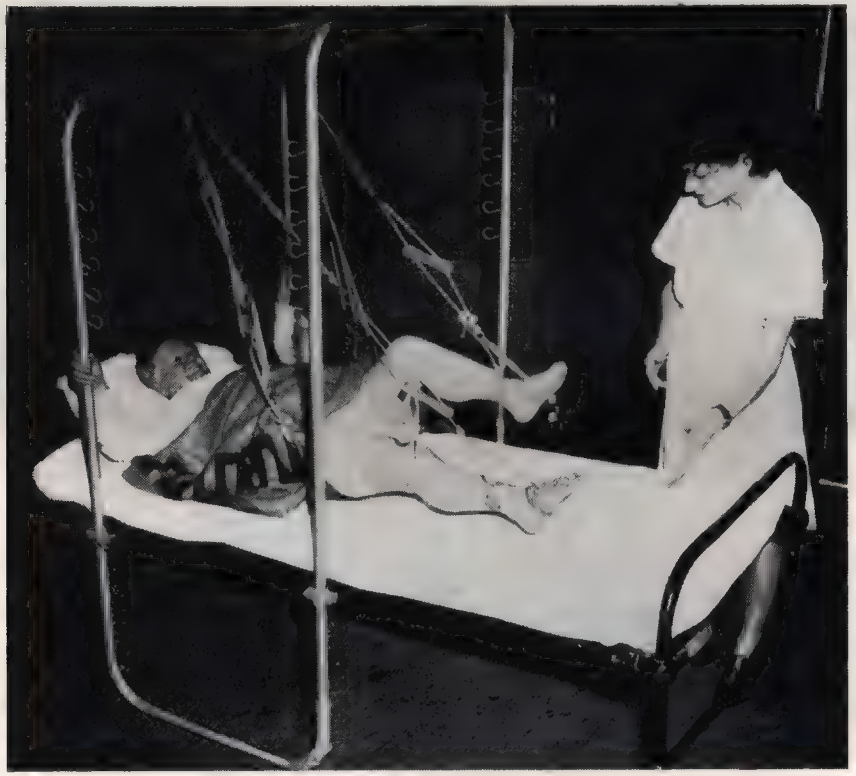
(a) How to use two springs without a rope to give a strong arm circling resisted exercise.

(b) How to arrange the patient to get strong resisted exercise for the back muscles, using the body belt, 100 lb. spring, and the foot-rest for counter pressure. As a pulley is fixed in the rope circuit *rotation movements* of the abdominal and back muscles are also obtained.

See also pages 243, 244, 245, 246 and 247 for further details of these Trunk Supported Exercises.

(b) THE MOBILE WARD UNIT

The " Mobile Ward Model " is a new design of apparatus which can be moved easily by pushing it along on its sledge-like base. It will span a 3-ft. bedstead, but when clamped to the frame of the bed it is absolutely rigid. When pushed sideways it will pass through an ordinary door or into a lift. The apparatus can also be clamped to fit a plinth.



[*Nursing Times*]

FIG. 276.—The Mobile Ward Unit.

The use of the apparatus for the geriatric group of patients.

Fig. 276 shows an aged patient who had been confined to bed for a considerable time, suffering from multiple arthritis. After a period of rest and remedial treatment she went on to exercises which would prepare her for

a normal existence at home. Therefore all parts of the body were put through useful movements. She greatly enjoyed the exercises and fully realized that if she practised them in bed she would feel much benefit when she had to leave the hospital to go home.

(*a*) (*b*)

Fig. 277.—The Mobile Ward Unit.

(*a*) The correct way to place the frame over a bed so that the lower end can be used by a patient to lift the body off the bed for strong exercise.

(*b*) A method of securing free and isolated movement to the humero-scapular joint. The patient actively rotates the arm by holding on to a cord and handle while the operator controls all scapular movements.

The two main things one would wish a patient to be able to do during convalescence at home are to walk and to use the arms for feeding, dressing and household duties. Therefore, the two most appropriate exercises to teach are " shoulder rolling " and " walking in bed." Both these exercises involve co-ordination. The weightless exercises and the recoil of the springs greatly lessen fatigue, so that much repetition can be tolerated.

The benefits to the general circulation are obvious : balance and control of the working muscles will lead to an increase of muscle tone ; the patient

will get on more quickly and safely, and with increased confidence, if this preliminary treatment is carried out in the wards.

Walking in Bed. For this exercise the patient lies on the back. The two legs and the pelvis are slung up so that the weight is transferred to the apparatus and they are free from contact with the bed.* The muscle work is alternate leg out-thrusting (as in walking) but there is also considerable action of the muscles of the pelvic girdle, abdomen, and lower back. If 50-lb. springs are incorporated in these rope circuits a buoyant movement is felt, involving resistance in one direction and a recoil of the springs in the other direction. This allows an easy repetition of the movements and reduces the feeling of fatigue. The patient can " walk " quite a long way in bed if she is sufficiently encouraged and is capable of using some imagination.

* Fig. 270, page 434, illustrates the arrangement of slings necessary for this exercise.

Appendix 2

POSTURAL DRAINAGE FOR CHEST CONDITIONS

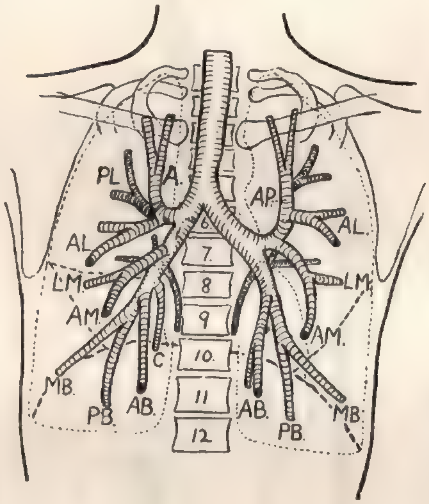
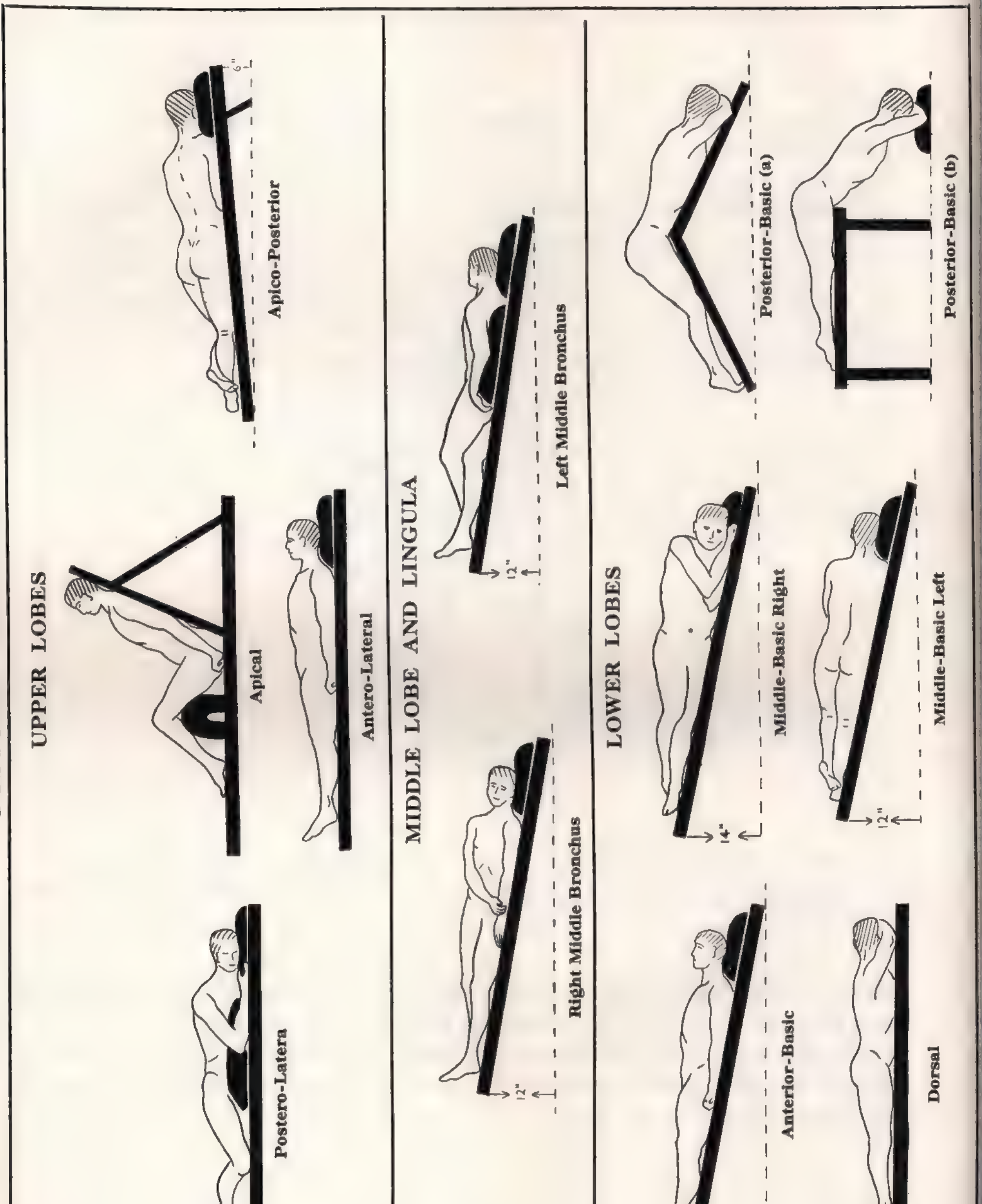


Fig. 278.—The Bronchial Tree

A: Apical. AB: Anterior Basic. AL: Antero-Lateral. AM: Anterior Middle. AP: Apico-posterior. C: Cardiac. LM: Lateral Middle. MB: Middle Basic. PB: Posterior Basic. PL: Postero-Lateral.

Postural drainage positions should be given with breathing exercises in such a manner that the chief bronchial tubes can be drained.

The instructions and the chart of the Bronchial Tree are taken from those issued by the Brompton Hospital for Chest Diseases, by kind permission of A. F. Foster-Carter, D.M., B.Ch.


POSTURAL DRAINAGE
UPPER LOBES
Apico-Posterior
6"
Apical
Antero-Lateral
Postero-Latera
MIDDLE LOBE AND LINGULA
Left Middle Bronchus
12"
Right Middle Bronchus
12"
LOWER LOBES
Posterior-Basic (a)
Posterior-Basic (b)
Middle-Basic Right
14"
Middle-Basic Left
12"
Anterior-Basic
12"
Dorsal

LOBE AND AREA DRAINED	*BRONCHI*	*POSTURE*
Upper Lobes		
(*a*) Upper parts	Apical	Sitting upright; with slight variations according to position of lesion, *i.e.* slightly leaning backwards, forwards or sideways.
(*b*) Front parts	Antero-lateral	Lying flat on back.
(*c*) Right outer and posterior parts	Postero-lateral	Lying on left side—horizontal—and then turned 45° on to face, resting against pillows to maintain position.
(*d*) Left upper posterior part	Apico-posterior	Lying on right side—and then turned 45° on to face—with pillows arranged to lift shoulders 12 in. from bed.
Middle Lobe (*Right*) Front, middle and lower parts of right lung.	Right Middle Bronchus	Lying flat on back, body quarter turned to left (*i.e.* 45°) maintained by a pillow under right side from shoulder to hip. Foot of bed raised 12 in.
Lingula Process (*Left*) Front, middle and lower parts of left lung.	Lingula Bronchus	Lying flat on back body quarter turned to right (*i.e.* 45°) maintained by a pillow under left side from shoulder to hip. Foot of bed raised 12 in.
Lower Lobes		
Front part	Anterior-Basic	Lying flat on back, buttocks can also rest on a pillow—and knees be bent—foot of bed raised 14 in.
Apex lower lobe (upper posterior part)	Dorsal	Lying flat on face, place a pillow under lower abdomen.
Outer parts	Middle-Basic	Lying on the (right or left) side—foot of bed raised 14 in., place pillow under patient just between hips and lower ribs.
Lower posterior area	Posterior-Basic	(*a*) Tipping frame (of wood with a mattress over it) made like a wide inverted "V" or the Nelson postural drainage bed. Angle of tip should be 45°. (*b*) Lying across bed, face downwards, legs up to hips supported on the bed and body leaning down towards the ground at an angle of 45°. The forearms rest on a folded rug or a pillow, and the head is rested on the hands. *Time:* this position not to be maintained for more than half hour—start with 10 minutes four times a day, add 5 minutes daily.
Time.—Most of these positions are maintained either for 1 hour 2–3 times a day or for ½ hour 4–6 times a day.		

* This information should be read in conjunction with Chapter XV and especially p. 305. Diagrams of postural drainage by the Hon. Mrs. Beccari, M.C.S.P.

Appendix 3

ARTHROPLASTY OF THE HIP JOINT

By S. G. Orme, M.C.S.P., Principal of the London School of Physiotherapy, the London Hospital.

Arthroplasty of the hip is one of the modern surgical procedures introduced by Dr. Smith-Petersen of Boston, Mass., U.S.A. The operation is performed for the relief of pain, gross limitation of movement and loss of function in the hip joint—following such conditions as Osteo-arthritis, Chronic rheumatoid arthritis, congenital dislocation of the hip, and ankylosing spondylitis.

PRE-OPERATIVE TREATMENT

The physiotherapist prepares the patient for operation by teaching breathing exercises, foot exercises of every type, and the control of quadriceps and gluteal muscles by static contractions. During this period the physiotherapist gains the patient's confidence and interest and is able to explain the future plan of exercises which will be taught after operation.

OPERATIVE PROCEDURE

The following is a brief summary of the surgical technique devised by Dr. Smith-Petersen and carried out by Mr. Alexander Law in this country. The incision is made over the front of the hip. The muscles are divided, particularly the two heads of rectus femoris, which are removed from their attachments, the hip-joint capsule is resected, the head is dislocated from the acetabulum. The head of the femur and acetabulum are then denuded of cartilage and made congruous with one another. A vitallium mould is fitted over the head, being free to move on the head of the femur and in the acetabulum. The muscles are resutured, the rectus femoris is attached to the gluteal fasci and the wound is closed. Following the operation the limb is suspended on a modified Hodgen splint with skin traction of 5 lb. weight applied.

POST-OPERATIVE TREATMENT

Breathing exercises are begun the day after operation and followed by free active toe flexion and extension, foot flexion and extension and quadriceps contractions. Gluteal contractions are taught separately and in a few days the two groups are exercised in a combined contraction. The patient is encouraged to practice these exercises before and after all meals, gradually increasing the exercise to five-minute periods each hour. Movements of the hip and knee joints are started after an initial period of rest. Assistance is

afforded by the support from the splint and the patient helps the movement drawing down a handle attached to a balanced series of pulleys and weights. At least half the full range of flexion of the hip and knee is obtained followed by full extension of the knee. This is practised regularly at least two or three times hourly. Four weeks after operation a more intensive regime is instituted, Dr. Smith-Petersen devised skating on a flat hinged wooden board for abduction and adduction of the hip. Suspension Therapy is also used to gain abduction and adduction and flexion and extension of the hip. If the complete suspension apparatus for the wards is not available, two balkan beams can be fixed lengthwise over the bed and two slings for each lower limb are used to support the legs.

Bilateral abduction and adduction is practised over an increasing period of time each day, up to twenty minutes for each period three times a day, so improving the range of the essential movement of abduction and increasing the strength of the abduction and adduction of hip and the extension of the knee. Similarly flexion and extension of the hip is practised in suspension with the patient in side lying and with the unaffected hip fixed in flexion.

This intensive muscle work is essential to provide sufficient support and stability for the newly formed hip joint, in preparation for weight bearing.

Progression of muscle work is achieved in suspension by arranging the point of suspension in such a way that abduction and adduction can be resisted in turn. The skating can also be resisted by tilting the hinged board, so making use of the effect of gravity on the limb for either abduction or adduction. All free exercises are practised at this stage, particularly prone-lying hip extension and prone-lying back raising, the patients also join in the ward classes in the morning and evening. After six weeks (post-operative) the patient starts cycling on the stationary bicycle for increasing distances each day, pedalling forwards and backwards with high and low saddle. Partial weight bearing is also started; the patient learns an alternate crutch and foot gait, moving the opposite leg and crutch alternately. As a change of environment it is now possible for the patient to be taken to the out-patient department, where cycling, walking, stair climbing, exercises in suspension, and skating are all practised, together with other patients who are carrying out the more advanced exercises in the later stages of treatment.

Further resisted exercises are introduced and the suspension therapy is used to give scientific progression. Spring resistance is used to increase the strength of the muscle groups round the hip joint by increasing the number of times the movements are performed, and the poundage of the spring. This intensive practice of exercises continues over twenty-four months, more and more weight being taken on to the hip, gradually progressing from

walking, and jumping on two crutches; to walking with two sticks, to walking with one stick and finally with no support. Once the patient can walk easily with two sticks it is not necessary for him to rely further on the physiotherapist. By this time he is completely familiar with all his exercises and should be able to carry on satisfactorily at home. As more weight is taken a few attendances to supervise the change from two to one stick may be necessary and again when sticks are finally discarded.

After full weight-bearing is allowed the patient is seen by the surgeon at regular intervals during the next two or three years. This very slow progression to full weight-bearing is considered by Dr. Smith-Petersen to be one of the most important considerations in the post-operative care.

Appendix 4

OSTEO-ARTHRITIS OF THE HIPS

By C. B. Heald, M.D., and F. L. Greenhill, S.R.N., M.C.S.P., of the Royal Free Hospital, London.

There are several varieties of this most unpleasant and disabling disease. Let us consider, for simplicity's sake, the variety that attacks people in the middle and later decades of life, and is limited to the hip joints; all the other joints of the patient being 100 per cent. well and active.

There have been a number of important changes in the medical and surgical approach to this condition. It is not so many years since an attitude of " you've had it " was largely prevalent. Palliative treatments by heat of various forms and massage and movements appeared to slow up the crippling and progressive flexion and adduction deformity of the thighs. Also, there was a period when X-ray therapy seemed to bring a considerable measure of relief. Alas, it was only when these patients were seen some two to three years later, it was realized that this treatment had been purely temporarily alleviative. Injections of the joints with lipiodol then had a short run, but were found to be unsatisfactory.

Surgical treatment as practised consisted of capsulectomy in some cases, and in others arthrodesis; but in the great majority of cases this disease " marched on." The surgeons then became dissatisfied with their results; in the case of arthrodesis because of the frequency of subsequent involvement of the other hip, and in capsulectomy because it gave only very temporary benefits of relief of pain and increased movements.

Surgery of the hip joints is now advancing as a result of improvements in arthroplasty ; by neurectomy, and by a more intelligent and rational method of injection of the diseased joint other than by lipiodol.

A number of these patients will, however, for various reasons, be suitable neither for arthroplasty nor neurectomy. In the remainder the injection of the joints by lactic acid, as introduced by Mr. Grant Waugh some twelve years ago, provides in a reasonable number a valuable addition to our means of alleviating some of the handicaps of this condition.

In the Royal Free Hospital Unit of Rheumatology, a combined attack on the disease was worked out for these patients. In general terms it is as follows :

Extension of the hip is applied for two weeks. During this period an attempt is also made to increase abduction. Injections of lactic acid with procaine are usually commenced and given at weekly or fortnightly intervals, sometimes for many months.

Physiotherapy consists of :

(1) Breathing, and general bed exercises, special attention being given to hip rotation.

(2) Heat, by means of true Inductothermy at a frequency of 12 mc. applied to the joint for ten to fifteen minutes daily, immediately prior to suspension exercises.

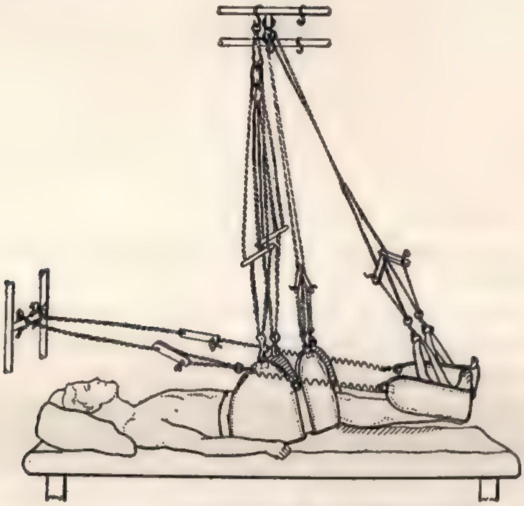
(3) Suspension therapy at least once in every 24 hours the extension is removed and the frame utilized to give oscillatory suspension therapy. The following exercises have been found useful to secure the best mobilization of the hips. The apparatus required is two narrow belts and ropes, with two spiral springs.

Method of Suspension.—The patient lies on his back ; one leg is treated first. A belt is wrapped round the foot and ankle to form a figure-of-eight and the other belt supports the thigh. These are connected to their ropes and springs and attached to hooks so that they are suspended vertically. When bilateral osteo-arthritis is present it is advisable to fix the other leg, by means of a sandbag or sling across the thigh, to prevent pelvic movement. If the movements are very limited, the physiotherapist sets up small oscillations in the springs by gentle intermittent pressure and relaxation on the thigh and lower leg, and encourages the patient to take over the movement. He should then be instructed to time his muscle contractions to correspond to the extension of the spring, and to relax with the recoil. When this is attained an effort should be made to increase the range of movement. These oscillatory movements can then be utilized to obtain abduction and adduction of the hip. When the other leg has been similarly treated, progressions can be made by performing co-ordinated movements of both legs. These

can be followed by fixing both legs together by a double belt at the thigh and a single belt round the feet. Stronger springs are inserted to take the additional weight.

Re-education of walking.—Equipment required :

4 narrow belts and ropes.
2 self-adjusting straps and ropes.
1 wide belt and two double ropes.
2 long spiral springs.



[*By courtesy of Messrs. Hodder & Stoughton*]

FIG. 279.—Re-education of walking in bed.

The patient lies on the plinth. Both legs are supported as for abduction and adduction of the hip joint and the ropes are then attached to hooks on the central cross-bar. In addition, the pelvis is slightly raised by means of a wide belt connected to the double ropes which are attached to the side bars of the frame. A narrow belt is now placed round the sole of each foot and connected to a spiral spring and single rope. Both ropes are passed backwards in a straight line and knotted to the head of the bed. The patient then thrusts alternately against the resistance of the springs.

The further stages of rehabilitation are re-education in walking, with the objective of freeing the patient, if possible, from sticks or crutches, and of securing proper balanced posture ; this last depending so largely on how much of the flexion and adduction deformity has been relieved by this method of combined attack.

It is, however, only by prolonged close attention to maintaining the range

of movement and improved muscle tone, with the patients full collaboration, that the best and most lasting results are secured.

It will thus be seen that these new approaches to osteo-arthritis give not only greatly increased hope for the sufferers but provide a vitally useful field for the physiotherapist.

Appendix 5

REHABILITATION AFTER INJURIES TO THE SPINAL CORD AND CAUDA EQUINA

Contributed by L. Guttmann, O.B.E., M.D., M.R.C.P.
Neurological Surgeon i/c Head and Spinal Injuries Centre, Ministry of Pensions' Hospital, Stoke Mandeville.

INTRODUCTION

Any severe lesion of the spinal cord always presents a disablement of great magnitude. The paralysis which inevitably follows a spinal cord lesion involves such essential functions as motor, sensory, vasomotor, bladder, intestinal, and sexual functions. Recollections of treatment of paraplegic patients in the past leave depressing memories of hopelessness and helplessness. One remembers apathetic men and women with sallow complexions : patients emaciated from septic absorption from foul-smelling pressure sores and urinary infection. The expectation of life for these unfortunate sufferers was generally assessed at not more than two years. Those patients who managed to survive were doomed to spend their lives as useless and unemployable cripples—professional charity cases in institutions or at home—with the poor consolation of perhaps a little basket-work as the only hope for the future. It is therefore not surprising that the subject of paraplegia has hardly been mentioned in publications on rehabilitation during former years. However, experience during recent years has shown indubitably that these cases, if treated properly from the beginning, are by no means hopeless. In fact, the modern principles of rehabilitation can be applied to most of these patients, to restore their will to live, in spite of great physical handicap, and win their hearts and minds back to activity and useful work, so that they can once again take their rightful places in social life. Since it has been realized more and more that everyone connected with the rehabilitation of a paraplegic is confronted in all stages of his work with the task of rescuing not only a broken body but also a broken personality,

definite progress has been made in the solving of a problem, hitherto considered as one of the most depressing in medicine. The first step forward in the systematic study of the whole problem in Great Britain was the setting up of spinal units during the recent war. One of these was the spinal unit at the Ministry of Pensions' Hospital, Stoke Mandeville, which has now developed into the largest of its kind in the United Kingdom and Europe. It consists of five male wards and one female ward, with about 120 occupied beds, and deals with both service and civilian paraplegics, and the methods of treatment and rehabilitation of paraplegics developed in this spinal unit have served as a guide to other hospitals and units concerned with the rehabilitation of paraplegic patients.

The following article is more or less a reproduction of the greater part of one of the author's articles on rehabilitation which was published in 1946 in the *British Journal of Physical Medicine and Industrial Hygiene.* The chief points in medical rehabilitation after spinal cord injuries are discussed, and emphasis is laid mainly on the physical restoration of the paraplegic patient.

PRINCIPLES AND OBJECTS OF GENERAL TREATMENT

The rehabilitation of paraplegics is a very complex process and includes a long series of activities, which fall into three main categories : (1) first-aid and early treatment ; (2) physical and psychological readjustment ; (3) permanent settlement and employment.

The patients were transferred to this centre at varying intervals after injury and in varying conditions, from first-aid posts, base hospitals, general hospitals, and other medical institutions. In the majority of cases their condition was serious, on account either of the initial spinal injury (with gaping wounds discharging cerebrospinal fluid) or of associated injuries to other organs, such as the lungs or intestines, or to the extremities. In numerous cases the spinal lesion was complicated by marked extension or flexion contractures of the paralysed limbs. A considerable number of cases, admitted at later dates after injury, showed signs of septic absorption, with anæmia and emaciation resulting from ascending urinary infection, pressure sores, or infections of other organs. Consequently, the treatment here has had to be very active from the very beginning, and has been multifarious.

The *leading principle* underlying our whole programme is activation and mobilization of all compensatory mechanisms in the paraplegic, in order to shift his psychomotor capabilities from the lower to the upper part of the body.

General Treatment

The chief objects to be pursued are as follows.

Avoidance of recumbency.

Every endeavour is made to avoid prolonged recumbency by encouragement of all forms of movement, even in the earliest stages after injury. This is of vital importance for the prevention of pressure sores and of the stagnation of waste products in the urinary tract, for the latter promotes ascending urinary infection and ultimately leads to formation of stones in the kidneys and bladder. Any form of fixation of these patients in plaster casts and, in particular, plaster beds, is strongly deprecated.

Nutrition

The restoration and maintenance of nutrition of the body at the highest possible level is another vital point. Many patients arrived here in a condition of profound nutritional deficiency, caused by septic absorption from huge pressure sores and by infection of the urinary tract. It is now well known that the loss of protein from oozing sores and urinary infection is very great ; it may be as much as 50 grammes. Indeed, some of these men on admission showed a state of malnutrition which could be compared only with that of the victims of Belsen Camp. Immediate and permanent attention must be directed to the restoration of a good nutritional condition, and this is done by means of repeated blood transfusions and of special diets rich in protein and vitamins.

Care of the skin

The condition of the skin in the paralysed insensitive parts of the body needs constant supervision, especially in the early stages, when tissue vitality and tissue resistance to pressure are lowered because of circulatory disturbance, and as the result of the traumatic shock and the loss of vasomotor control caused by the spinal cord lesion. Pressure sores, which develop in particular over the bony parts of the body, may be enormous ; they are one of the most serious complications and the commonest cause of sepsis and death after spinal injuries.

In order to prevent the formation of sores, or to promote the healing of those which have already developed, the patient's position must be changed completely at frequent intervals (1–2 hours). This must be carried out relentlessly, day and night, despite reluctance to disturb the patient's rest. Besides change of posture, redistribution of pressure—by nursing patients on special beds, mattresses and pillows—is of the utmost importance. Infection of sores is combated by various chemical and mechanical procedures, according to the nature of the infecting organisms. Necrotic portions of

pressure sores are excised carefully, and the excision is followed by daily dressings.

Care of the bladder

This is just as important as the care of the skin, for ascending urinary infection from the paralysed bladder is the other main cause of sepsis and death in patients with spinal cord lesions. It is beyond the scope of this paper to go into details of the various local methods which are employed to counteract urinary infection.

Whatever local methods are used in the treatment of a patient with paralysed bladder, two of the main factors in the treatment (particularly in the prevention of calculus formation) are the shortening of the duration of the recumbent position and the restoration of the best possible physical fitness of the man. The former is more feasible in cases of gunshot injury, as the supporting power of the spine has not been interfered with in the majority of cases.

Care of the bowels

The care of the bowels also needs the greatest attention throughout, and this is exercised by the use of regular enemas, as well as of special diets and medicaments. We have often admitted patients who have stated that they had regular motions, whereas rectal and abdominal investigations revealed masses of old and hard fæces. This clearly shows that the motions in such cases are due only to overflow, and this fact always has to be remembered in dealing with paraplegics.

Psychological aspects

The mental disturbances found in paraplegics in the Centre can be classified into two main groups, as under.

(1) *Organic mental disorders.*—These are caused by infective-toxic processes; they are associated mainly with the infection of the urinary tract and of other organs, and with septic absorption from pressure sores.

(2) *Reactive mental disorders.*—The sudden conversion of a vigorous man into a helpless cripple naturally leads to severe psychological shock and reactive depression, due, on the one hand, to his feeling of hopelessness and, on the other hand, to a sense of resentment against his fate. In some cases, also, there is a tendency towards underestimation of the extent of his disability, with consequent disillusionment and disappointment later.

Psychiatric treatment.—From the very beginning, the patient's mental condition needs careful attention and psychiatric handling; the development of a strong doctor-patient relationship is the most important factor in preventing and counteracting these disorders, especially the apathy and

inactivity. The patient's confidence has to be gained and his co-operation secured. The staff has to be taught to understand all the psychological reactions and to help in their treatment. The creation of a cheerful atmosphere and good morale in the ward is of vital importance. The whole unit must be impregnated with enthusiasm, for this inspires the patient to co-operate to the full.

Any scheme which neglects this principle is doomed to failure. Indifference, anxiety, resentment, and resignation, as well as self-deception, all have to be watched for in later stages, because all these reactions may impede successful rehabilitation and impair the patient's working efficiency.

PHYSICAL RESTORATION

One of the dominant activities of the medical officer in charge of the Spinal Centre, be he physician or surgeon, is the planning and supervision of the physical treatment of paraplegics, for upon his intimate knowledge of each case and, in particular, on his expert functional and psychological analysis of the patient's disability depend indication, duration, and modification of the various forms of physiotherapy. The physiotherapy department is never called upon blindly for " physiotherapy, massage or remedial exercises." In every case a constructive programme has to be devised, and the physiotherapist in charge of the case receives detailed instructions about the patient's disability and the treatment to be applied.

Undoubtedly, the physiotherapist has become one of the most important members of the team concerned with the rehabilitation of paraplegics. It is imperative that his (or her) work be done in concert with that of the other members of the team : the nursing staff, the physical training instructor, the occupational therapist, and the vocational training instructor.

The two fundamentals in the physical treatment of paraplegics are early start and continuity. The aim of physiotherapy in these cases is to develop the man's fitness to the highest possible degree, in order to restore his independence to as great an extent and as quickly as is possible. The chief objects to be pursued are (1) prevention of contractures and of atrophy in the paralysed parts of the body ; (2) compensatory training of normal parts of the body.

Position of the paralysed limbs

In the early stages the physiotherapist has to assist the nursing staff in keeping the paralysed limbs in a proper position, in order to prevent adduction of the legs, drop-foot, claw-toes, and pressure to the neck of the fibula.

Permanent fixation of paralysed limbs in any position is discouraged. In lesions of the cord, in particular, the permanent position of the lower limbs in adduction and semi-flexion, caused by placing pillows under the knees, is

deprecated, as this must inevitably lead to adduction and flexion contractures. Flexion contractures of the knee-joints in themselves promote violent flexor spasms, once the flaccid stage of the cord injury has passed and the automatic reflex activity of the spinal cord below the level of the lesion has developed. In cases of cauda equina lesions, if the care of the patient's position in the early stages has been neglected, contractures often develop in flexion of the hip, extension of the knee, and adduction of the leg. This occurs in particular in lesions below L.2 and L.3, in which the intact muscles —ilio-psoas, quadriceps, adductors, and internal rotators—have an unrestrained over-action due to the paralysis of their antagonists.

The most deleterious type of contractures was found in the cases admitted in plaster beds, in which the patients had lain for months. At the beginning of the recent war plaster beds were advocated for the prevention and healing of pressure sores. Experience has shown that not only have plaster beds proved to be no better method for encouraging the healing of the sores, but in numerous cases they have actually promoted the development of sores. In addition, the contractures of the joints and the atrophy of the tissues of the back caused by this type of fixation, were profound. Patients who had recovered from cord or cauda equina symptoms were frustrated because of the superimposed stiffness of the joints and of the distorted pelvis, developed in the plaster beds. It took months and years of hard work to remedy, or at least diminish, the damage done by this form of fixation. It is therefore obvious that plaster beds are strongly deprecated at the Centre, as being absolutely contrary to the fundamentals of rehabilitation in paraplegics.

Passive movements

Passive movements of all joints of the paralysed limbs are begun immediately after injury and are carried out once or twice daily in order to prevent contractures and promote better circulation in the paralysed limbs. Better circulation can be promoted also by massage, which, however, has to be carried out with caution, because of the risk of damage to the paralysed tissues. For all patients admitted to the Centre in the later stages after injury, in whom more or less severe contractures had already developed, regular passive movements have proved to be most beneficial in overcoming them. The effect of treatment is judged by regular measurements every week or fortnight and can be charted.

In cases of cord lesions, passive movements of the paralysed limbs are carried out daily; not only is this done during the stage of spinal shock, when the paralysis is of flaccid type, but the movements are continued regularly in the spastic stage in order to prevent flexion or extension contractures, which are serious complications of reflex spasticity.

Electrotherapy

In lower motor neurone lesions, such as those of the cauda equina and cervical roots, daily electrical stimulation is beneficial in promoting better circulation and delaying atrophy of the denervated muscles. Electrotherapy, in the form of galvanism and faradism, is used in these cases as an exercise to the paralysed muscles in place of their normal contractions. It is begun as early as possible (seven to ten days after injury), and is applied in increasing numbers of contractions (200–600 to each muscle group). A remarkable finding with this regular electrical exercise, in our cases of cauda equina lesions, was that the paralysed muscles retained their response to faradism for several months, even in those muscles which never showed any recovery of function. From experience gained on the subject of electrotherapy in cauda equina lesions, it can now be concluded that if, after four to six months, return of function is confined to muscles supplied by the upper lumbar roots, which are important for standing and walking, electrotherapy should be centred solely on those muscles and may be discontinued for the others.

Treatment of flexor spasms

This problem in the treatment of spinal cord injuries requires more detailed discussion here. Violent reflex spasms—in particular, flexor spasms of the lower limbs—develop in many cases once that part of the spinal cord which is below the level of the lesion has recovered from spinal shock and has taken up its autonomous function, unrestrained by the control of the pyramidal tracts and other centrifugal pathways. A number of intrinsic and extrinsic factors may act as nociceptive stimuli, which, entering the spinal cord below the level of the lesion as afferent impulses, are transmitted to the anterior horn cells and other efferent systems and elicit a mass response, of which the reflex spasms of the motor apparatus is one of the many associated conditions.

The importance of the various intrinsic and extrinsic factors in lowering the threshold of reflex activity of the damaged spinal cord must be remembered in spinal injuries from the onset, in relation to the prevention and treatment of flexor spasms. Some of these factors may be mentioned here. Distension of the paralysed bladder is a violent initiator of the reflex spasms, and the smaller the capacity of the bladder, the smaller the amount of urine necessary to elicit a reflex response. Of equal importance is the distension of the rectum and colon by stagnation of fæces. Indeed, the beneficial effects of evacuation of an overloaded rectum by means of enemas on the intensity of flexor spasms are often very remarkable, as is also the prevention of stagnation of fæces in higher parts of the colon by the administration of liquid paraffin. Any intervening infection (in particular that of the

urinary tract), septic absorption from pressure sores, and anæmia also lower the threshold of reflex activity of the spinal cord, and undoubtedly the successful treatment of these factors also diminishes the intensity of reflex spasms. The importance of the irritation of sensory organs in contracted joints and tendons for the facilitation of spasms is another factor and is already mentioned above. The prevention of contractures from the onset as well as their continuous treatment once they have developed, by regular passive movements, have proved to be most successful in our cases. It must be emphasized that even extreme degrees of flexor spasm and contracture in paraplegics can be greatly improved by this conservative measure, especially if the passive movements are carried out in a continuous bath, that is, under water in a bath kept at a uniform temperature.

A number of surgical measures, such as division and elongation of tendons of the flexor muscles, division of the adductor muscles, division of the obturator nerves (anterior and posterior roots), have been recommended. They certainly have their indications in selected cases and have proved to be successful, especially if followed by passive movements.

Adaptation therapy of normal parts of the body

General principles of compensatory training

Passive movements of the paralysed limbs are given in conjunction with exercises for the normal parts of the body. These are carried out from the early stages, with a view of readjustment of the vasomotor control to postural changes and to the over-development of those muscles which are essential for the patient's upright position, as well as of those which have a synergic function, in relation to the paralysed muscles and can compensate for their loss. For patients with lesions of the lower thoracic cord, conus and cauda equina, with complete paraplegia, everything is done to strengthen the activity of the abdominal muscles, and of the erector spinæ, the latissimus dorsi and the quadratus lumborum muscles, for the following reasons.

(1) The combined operation of these muscle groups will greatly improve the balance and mobility of the trunk.

(2) Strong action of these muscles will help to shift the psychomotor capabilities in the paraplegic from the paralysed distal parts to the upper parts of the body, because it makes the activity of the normal upper limbs more effective, owing to the increased fixation of the trunk.

(3) The combined operation of these muscle groups will restore the capacity of the paraplegic to walk between parallel bars or on crutches, by means of pelvic tilting, or by promoting swinging movements of the trunk. To keep the balance in these cases, it is necessary to fix the knees with light bivalved appliances and splints (and later with calipers), keeping the feet

at the correct angle by means of simple toe-springs ; thus the paralysed legs are being used like stilts.

(4) The training of the abdominal muscles is of great importance also for the restoration of bladder function and the re-education of the bladder. It must be remembered that, in these distal lesions, voluntary micturition is carried out with the help of pressure of the abdominal wall. It is obvious that the stronger is the power of the abdominal muscles, the sooner and more

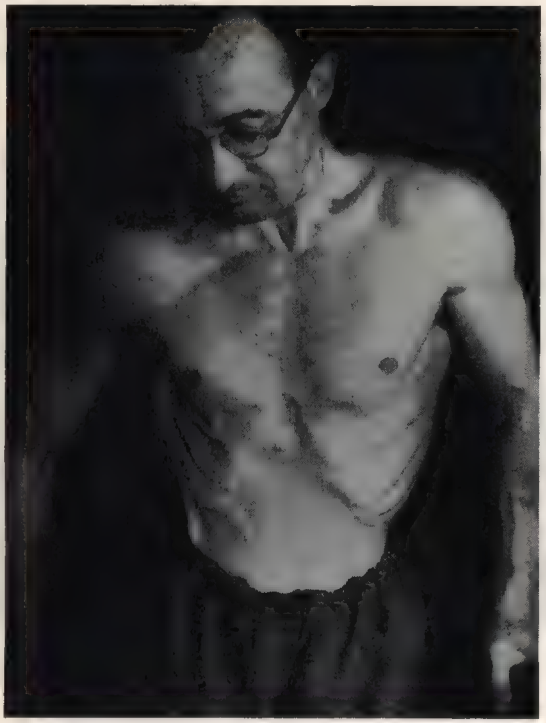


FIG. 280.—Hypertrophy of pectoralis muscles in a case of complete transverse spinal lesion at Th.6. Note the contrast between this hypertrophy and the extreme atrophy of the intercostal and abdominal muscles.

effective is the voluntary micturition, and the sooner can the suprapubic drainage be abandoned. The same principles apply also to the restoration of bowel action in paraplegics.

(5) Finally, the training and over-development of the abdominal and back muscles is of great value in restoring the sexual function of paraplegics. Experience in the Spinal Centre has shown that these men are by no means as sexually impotent as was previously thought. The training of these

muscle groups is one of the main factors in the sexual rehabilitation of patients with low thoracic and cauda equina lesions. This achievement naturally has an enormous psychological effect on the man.

The photograph shown in Fig. 280 illustrates the over-development of muscle groups of normal parts of the body, achieved by compensatory training in cases of complete lesions of the spinal cord at various levels. It shows the hypertrophy of the pectoralis muscles and shoulder muscles (especially the trapezius, teres major and latissimus dorsi) in a case of complete transverse cord lesion at Th.6, after fracture-dislocation of the tenth and eleventh dorsal vertebræ. Note the marked contrast between the hypertrophic muscles and the profound atrophy of the intercostal and abdominal muscles.

Fig. 281.—Swinging exercises in slings in a case of complete transverse spinal lesion at Th.3.

Special methods of compensatory training

The following are some of the special methods applied for compensatory training.

Sling and spring exercises

Auto-assisted movements with the help of suspension in slings are used and exercises against resistance by means of pulleys and weights are employed ; each ward in the Centre is equipped with one or two sets of Guthrie Smith apparatus. They have proved to be very effective in all kinds of spinal cord lesions, the duration and intensity of the exercises being gradually increased.

Swinging exercises in slings are of great value, in particular in lesions of the upper thoracic cord, for two reasons (see Fig. 281).

(1) They promote over-development of the pectoralis, latissimus dorsi, trapezius and other muscles of the shoulder girdle, which, in these high lesions, are the only muscles which will develop and guarantee the balance of the body in the upright position. A young patient with a complete transverse spinal lesion at Th.3, after hypertrophy of the latissimus dorsi, pectoralis, and serratus anterior muscles, has learned not only to swing his whole body with these muscles, but also to stop swinging immediately on command.

(2) These exercises are of immense importance for the *restoration of vasomotor control during postural changes*, which is crippled in cases with these high lesions by the interruption of the efferent part of the splanchnic outflow.

It has been discovered that gravity has a profound effect upon the blood circulation, especially upon blood pressure, in cases of high thoracic cord lesion in which the vasomotor control in the splanchnic area is interrupted or impaired. Such a patient, when raised from the horizontal to the upright position, will tolerate this position, especially standing, very badly, owing to the profound disturbance of his postural adaptation mechanisms. This maladaptation results in rapid and uninhabited accumulation of blood in the abdominal area and in the lower limbs, with resultant decrease in the supply to the central veins, and consequently, insufficient cardiac output. The blood pressure shows a rapid and steep fall, the pulse rate is raised to the highest level, and syncope follows in a few seconds or minutes. However, a patient with a high thoracic lesion, but well trained by means of swinging exercises, has much less difficulty in overcoming postural circulatory disturbances. It must be assumed that the forces of adjustment which are regulated by the carotid sinus and other blood collectors have been developed sufficiently to act as "emergency adaptors" in order to compensate for the loss of the splanchnic control. In cases of high cord lesion, adaptation to the upright position can be facilitated also by preventing blood from accumulating in the lower parts of the trunk by the use of an abdominal binder or belt.

Swinging exercises can be carried out also in an upright position between parallel bars. They are of value in lower cord, conus, and cauda equina lesions, in order to improve the strength of the abdominals and other muscles which move the pelvis.

Dressing exercises

Another example of exercise to adjust paraplegics to postal changes whilst in bed, and to prepare for their future independence is a dressing exercise.

The paralysed patient is taught and encouraged to dress himself in the minimum of time, the procedure including hoisting himself from his bed to his wheel-chair, either with or without the aid of the chain and handle fixed over his bed.

The record time for dressing achieved so far, by a patient with a complete lesion at Th.11 resulting in complete spastic paraplegia and sensory loss, is just under 4 minutes.

Balance exercises

As soon as possible—in some cases of complete transverse lesions, as soon as five to eight weeks after injury—the patient is promoted to a wheel chair. This, in itself, adds greatly to his range of activity. In certain cases—especially those with complete lesions of the mid and upper thoracic region, in which most or all abdominal and trunk muscles are paralysed—special exercises with arm-raising in various directions in sitting position in front of a mirror are added ; these have proved to be invaluable in restoring and improving the patient's balance.

Incidentally, the first patient of the Centre on whom this type of exercise was tried out was a case of poliomyelitis, with paralysis of almost all abdominal and back muscles.

On admission, this poliomyelitis patient was absolutely unable to sit up and keep the balance of his body without fixation of the hands at the edge of the bed. After continuous balance exercises for 3 months, he succeeded in sitting up without any support from his arms. He was able to lift up his arms forwards and sideways above the horizontal, preserving his balance and keeping his body straight.

Walking exercises

When the muscle power in the normal parts and the balance of the body have improved sufficiently, standing and walking exercises are begun between parallel bars or in walking chairs, followed by walking on arm and elbow crutches. The exercises are carried out first in the ward, in order to encourage other patients who are not so far advanced. They are continued later in the physiotherapy department and in the long corridors of the hospital, the time and distance of walking being gradually increased. In certain cases rhythmic walking to music has been included in these exercises and has proved to be beneficial.

Naturally, the walking capability of a paraplegic—especially with a cord lesion above Th.10 segment—will always be very limited, but patients with lesions below that level—for instance, Th.12, with complete paralysis of both lower limbs and sensory loss below Th. 12/L.1—have succeeded, with training,

in walking 250 yards in $13\frac{1}{2}$–16 minutes, on arm crutches. The gait, in these cases, is that of a tripod action of each of the two crutches, maintained by alternate tilting of each side of the pelvis upwards by the use of the abdominal muscles (as illustrated in Fig. 282). Range and speed of walking can be increased if the propulsion of the body is carried out by swinging movements with the aid of arm crutches. The higher the spinal cord lesion, the more

FIG. 282.—Walking exercise on elbow crutches in a case of complete transverse spinal lesion at Th.12. Note the walking calipers; the weight of each is 2 lb. 9 oz.

is the propulsion of the body achieved by the isolated action of the muscles of the shoulder girdle, but however small the walking capabilities of a paraplegic may be, it will increase his range of activity and independence, especially when he is discharged from hospital. Moreover, the psychological effect of this achievement on the man—to be once again on his own feet—is immense.

Calipers.—Whatever type of caliper or brace may be indicated, the greatest attention should be paid to its weight, which should be as small as possible. This point is of vital importance in the restoration of the walking capacity and independence of paraplegics. The metal parts of the caliper should be made of duralumin, or even better, of hiduminium, which has a higher degree of durability than has duralumin. It must be remembered that these men have already to lift and to move the paralysed part of the body with the remaining normal muscles, and it is therefore quite obvious that every ounce of additional weight counts and means a further burden to the patient, causing fatigue and incapacity.

The same principle applies to the employment of crutches, especially elbow crutches, which often are too heavy and which also should be made of duralumin or hiduminium. When a man's very ability to walk depends upon these appliances, I consider that only the best should suffice and that " economic considerations " should be of secondary importance.

Games

Bed and ward games.—Games are very important in the physical and psychological readjustment of paraplegics. A large number of games, such as ball games (including punch-ball), darts, snooker, and skittles, can be adapted to the limited abilities of paraplegics. Ball games are begun in the ward whilst the patient is confined to bed on account of pressure sores and urinary infection; they are not only enjoyed by the patients, but have proved to be very successful in promoting activity; they provide good exercise in the development of the shoulder and trunk muscles. Every ward is equipped with a dart-board in order to give those patients who are " up " in their chairs the opportunity to play during the day or in the evening; matches have shown clearly that a paraplegic can compete easily with a normal person in this game.

Wheel-chair polo.—I have improvised and introduced a special form of polo, played in wheel-chairs. This wheel-chair polo not only exercises the whole of the upper part of the body and promotes great improvement in the circulation in both the normal and paralysed areas of the body, but also requires quick thought and good judgment, and thus keeps the man's intelligence and concentration lively.

Cultural entertainments and recreation

Various forms of cultural entertainment, such as regular cinema shows, concerts, and lectures on the arts are also provided.

TRAINING AND RESETTLEMENT

Along with the physical readjustment of paraplegics goes rehabilitation by means of work.

Occupational therapy

Occupational therapy is begun whilst the patients are confined to bed in the early stages of treatment when they are still immobile because of pressure sores and urinary infection ; it takes the form of toy-making and other simple handicrafts. All those connected with occupational therapy for paraplegics, no matter in what capacity, must understand clearly that the purpose of this therapy is not merely occupation as a diversional measure. It has great value in the development of the mobility and dexterity of the fingers and arms, upon which the future vocation of a paraplegic will depend in large measure. This work, therefore, represents the first step in the patient's industrial rehabilitation.

Early vocational training

In time, however, patients crave for some more serious employment, and pre-vocational training has been begun with patients still confined to bed ; it includes leather work, precision engineering, watch-repairing, and correspondence courses in commercial arts, economics, banking and Law.

As soon as a patient is able to get up, he attends daily at the occupational therapy department and workshops, where training is given in carpentry, shoe-repairing and precision engineering, the benches and tools being adjusted to the individual patient's disability. This work is graded and is correlated with the physical improvement of the man and with his previous personality.

Resettlement in industry

Training centres.—At a not too distant date the Ministry of Pensions, in co-operation with the Ministries of Works and Labour, will establish a training centre near London for patients with spinal cord injuries, where their training can be continued in nearby factories until they can be discharged to permanent jobs.

Permanent residential settlements.—There is a group of paraplegics who will not be able to return to their homes. For these, the Ministry of Pensions will establish permanent settlements adapted to their disabilities, in which married and unmarried patients can live in sheltered conditions, and from which those who are sufficiently well can go out in their wheel-chairs daily to neighbouring factories or others places of employment and earn their living in a normal manner.

Domestic resettlement

Another group of patients will be able to return to their homes, if these can be adjusted to their disabilities. The British Legion has agreed to co-operate, and will either adjust existing houses by widening doorways, building ramps and putting in bathrooms downstairs, or when the housing shortage is less acute, by building special bungalows. Recently, the British Legion has taken over Walton House in Aylesbury, an old rectory, and turned it into a " Home " in order to give married spinal-cord invalids, whose own houses are not yet adjusted for the reception of paraplegics, the opportunity of spending several weeks there with their wives and children in an atmosphere identical with or similar to that in their own homes. At my suggestion, the British Legion has agreed also to admit unmarried men with their parents, for the same purpose. During their stay at Walton House the men remain under the medical supervision of the Spinal Centre, and the wives and parents are well schooled in the efficient handling of their paralysed husbands and sons. So far, this experiment has proved to be successful.

Once a paraplegic is discharged from hospital, every endeavour should be made to find employment for him—or to help him to continue vocational training in training centres or other institutions—as quickly as is possible. Any undue delay might greatly endanger the success of the medical rehabilitation of a paraplegic and might lead to his sinking back into a state of inactivity and apathy.

Appendix 6

THE POST-OPERATIVE TREATMENT OF GYNÆCOLOGICAL CASES

By Ida Shires, M.C.S.P., T.M.G.
late of Charing Cross Hospital, London

The post-operative treatment of gynæcological cases requires well trained and experienced physiotherapists, who must be capable of adapting the treatment to the individual ; encouraging the timid, and restraining the adventurous patient. Gynæcological cases are divided into two classes, abdominal and minor operations, the latter being performed for the repair of various degrees of prolapse of the uterus and the vaginal walls due to weakening of ligaments following confinements.

The main abdominal operations are :—

(*a*) *Sub-total hysterectomy*, the removal of the body of the uterus only, leaving the cervix in the vaginal vault.

(*b*) *Total hysterectomy*, complete removal of the body and cervix of the uterua.

(*c*) *Wertheim's hysterectomy*, removal of the uterus, cervix, fallopian tubes and ovaries and the adjacent lymphatic vessels and glands and also a cuff of the vagina. This is an extremely serious operation.

(*d*) *Ovariotomy*, surgical removal of cysts or tumours of one or both ovaries.

(*e*) *Oophorectomy*, surgical removal of an ovary.

(*f*) *Salpingectomy*, removal of a fallopian tube.

The Minor operations performed for the various types and degrees of uterine prolapse are :—

(*a*) *Anterior colporrhaphy* performed for the repair of a cystocle, which is a hernia of the bladder, which stretches the anterior vaginal wall.

(*b*) *Posterior colpo-perrineorrhaphy* performed for the repair of a rectocele and torn perineum. The rectocele is a prolapse of the posterior vaginal wall into which a portion of the rectum herniates. It is caused by over-stretching of the pelvic floor and rupture of the perineal body in childbirth.

(*c*) *Fothergill's operation* for the repair of a vault prolapse, a condition in which there is a general tendency for the uterus to be displaced downwards, owing to weakness of the trans-cervical and utero-sacral ligaments and the pubo-cervical fascia. On pelvic examination the cervix is found low down in the vagina and if grasped by vulsellum forceps is easily pulled down to the vulva.

The aims of all physio-therapeutic treatment are :—

(*a*) *Breathing exercises* to prevent pulmonary complications. These exercises have a calming effect on the patient and also in the early post-operative days help flatulence, a distressing symptom following many surgical operations.

(*b*) *Improvement of the circulation* in the legs to avoid white leg (phlegmasia alba dolens) and other circulatory complications by means of simple active movements which also help to keep the muscles in good tone and so prepare the patients gradually for standing and walking again.

(*c*) *Strengthening* of the abdominal and perineal muscles by careful instruction of the patients as to the correct posture for standing, sitting and walking. The latter is most important as so many patients tend to stoop when they are first allowed up, particularly if they have not had previous treatment for their abdominal muscles, which are therefore weak, and also owing to the

fact that they are afraid to stand upright in case they stretch their abdominal scar. This bad posture very often leads to back-ache from which so many gynæcological patients suffer.

Outline of Scheme for treatment for the Abdominal cases.

These patients are nursed in Fowler's position as soon as they have sufficiently recovered from their anæthesia, and are not disturbed for the first few days for the treatment being given in this position.

Breathing exercises should be taught if possible the day before the operation, when the patient is better able to understand the instructions given to her and is therefore easier to instruct. If however the patient is not available the day before operation, then she should be taught the day after and at the same time be encouraged to do active foot bending and stretching and foot rolling exercises, 10 to 20 times, according to the condition of the patient.

Third day after operation, add gentle kneading to the legs and active foot movements, without removing the knee bolster (donkey), also quadriceps contractions and gluteal contractions.

After the clips have been removed add the following exercises :—

(1) Abdominal contractions

(2) Gluteal contractions

(3) Legs crossed, squeeze thighs together using adductors and muscles of the pelvic floor.

Ten days after the operation and onwards add the following :—

(1) Legs crossed, squeeze thighs together, contract abdominal muscles and gluteal muscles. Add one or two exercises daily to ensure that the following muscles are used :—

(*a*) Straight abdominal muscles
(*b*) Lateral abdominal muscles
(*c*) Oblique abdominal muscles.

The day before the patient is allowed to sit up, she should be instructed to sit with her legs hanging over the side of the bed and do the following exercises.

(1) Foot bending and stretching exercises.

(2) Alternate knee bending and stretching

(3) Double knee bending and stretching

(4) Contract abdominal muscles

(5) Squeeze thighs together and tighten the perineal and abdominal muscles.

When the patient has been up for a day or two add the following exercises sitting on a chair :—

(1) Any simple exercises for flat feet

(2) Alternate trunk side flexions

(3) Alternate trunk rotation

(4) Trunk bending forwards and raising vertebra by vertebra. At the upright position contract the abdominal muscles.

The exercises should be continued in the sitting position for the next few days and finally in the standing position. The trunk exercises with side flexions and rotations should now be taught with the abdominal muscles pulled in, i.e. by the rectus muscle, special attention being paid to the correct tilt of the pelvis in order to ensure correct posture.

Perineal cases.

These patients are usually nursed flat with one pillow only for the head for about 10–14 days. They are not actually so ill but suffer more actual pain, and therefore are not able to do so many exercises at the beginning, but when once the first stage is over they recover well. The treatment may be given on much the same lines as for the abdominal cases but exercises for the perineal muscles should not be given before the 10th to 14th day after operation, as they would be very painful to the patient and might be a possible cause of stitch breaking. The point which cannot be stressed too much in all cases is the great importance of teaching correct posture, the exercises are only a means to that end.

Appendix 7

THE AUTHOR'S BEDCHAIR

(Patent applied for)

Fig. 283.—The "Bedchair"

The bed-chair acts as a powerful *lever* and is of equal assistance to the patient or the nurse. It has four principal uses:

1. It supports the body in comfort while reading, eating, or reclining on the back or side in bed.
2. It enables heavy and relatively helpless patients to be dealt with by a nurse single-handed for such routine matters as washing, treating pressure points, and placing a bed pan or air ring under a patient.
3. It encourages *movement* of all joints and it is therefore a rehabilitation apparatus for use in convalescence.
4. It is a *carrying chair*—two persons can lift and carry a third.

Appendix 8

THE AUTHOR'S HOIST

(Patent applied for)

The Hoist is an apparatus designed to assist anyone who has to look after and care for an incapacitated patient. Such a patient can be lifted out of bed, lowered on to a couch or stretcher trolley, and turned while in bed. All these can be done without involving any discomfort to the patient or lifting strain to the nurse. The nurse stands with the left foot on the frame, facing the turning handle and raises or lowers the patient as required.

The Apparatus consists of an independent steel frame which fits over a three-foot bed ; it stands about 6 foot high and is three foot long. More length is obtained by sliding out extension tubes which then support the head and legs. (These tubes are pushed back when not in use).

The apparatus is moved about by sliding it on or off the bed or couch or it can be moved elsewhere. When the patient is in the Hoist the whole is moved as one unit. (Castor wheels can be fitted to the Hoist if required).

The Lifting Gear consists of a *worm drive* acting on bowden wires and a turning handle by which the square grid is raised or lowered. The patient is attached to this grid by canvas belts and cords in what is termed a " split hammock." The *belts* support the head No. 1, shoulders No. 2, waist No. 3, hips No. 4, knees No. 5 and feet Nos. 6 and 7. The *cords* are slipped over strong hooks which are fastened to the grid. When all are in place the patient is hoisted up from the bed.

Instructions for hoisting

The belts for *head* (No. 1) *waist* (No. 3) *knees* (No. 5), and *feet* (Nos. 6 and 7) are placed in position flat and without wrinkles under the patient. The apparatus is then pushed over the bed so that it lies squarely over the patient's abdomen (i.e. centre of gravity). The grid is now lowered so that the belts and cords can be slipped over appropriate hooks on the grid. Now it is time to hoist the body about two or three inches so that the shoulder No. 2 and hip No. 4 belts can be more easily slipped into their places under the body, the grid must be lowered in order to pick up these belts and cords. The patient can now be hoisted to the required position. This should be sufficient to clear any obstructions—such as the foot of the bedstead.

To *make the bed* the whole apparatus *including the patient* is pushed away from the bedstead—the bed can thus be properly made and the mattress turned.

Photos by *Nursing Times*, taken at St. Mary's Hospital, London.

FIG. 284.—The "Hoist" over bed and patient.

FIG. 285.—Patient being lifted up.

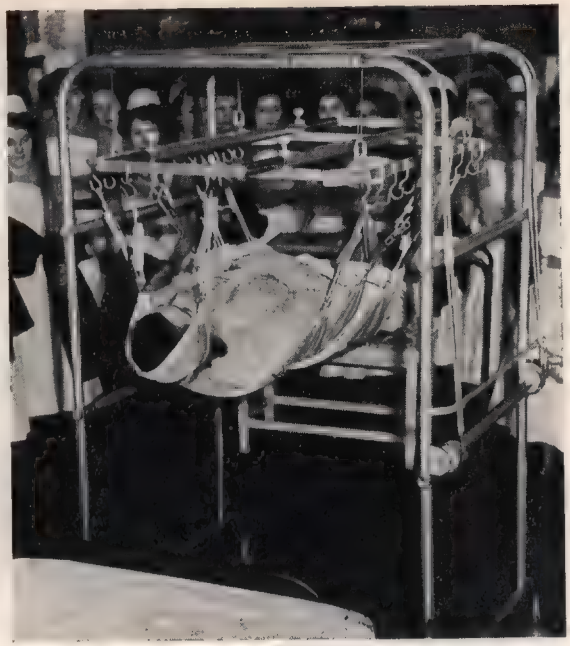


FIG. 286.—Patient drawn away from the bed while hoisted.

FIG 287.—Patient being turned in bed.

To lower the patient on to a couch, or a stretcher, is now an easy matter if the couch is placed end-on so that the apparatus can be pushed over it. When replacing the patient on to the bed it is as well to push the apparatus high up so that the head is lowered on to the pillows (this will save a manual lift later on).

To turn a patient in bed after hoisting, lower the whole grid till all the cords are slack, then take off all the cords on *one* side (say the right side). Cross the patient's legs (left over right) and remove the head belt. Now hoist up again and the left side cords will go taut, this will gradually and gently turn the body over on to the right side. The nurse should control the turn with one hand on the shoulders, and should see that the legs are comfortable, she should push the body past the middle of the bed before turning so that the patient comes down in the bed centre and not as shown in the illustration.

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